REPORT OF

THE BUREAU OF MINES, 1905

VOL. XIV. PART I.

CONTENTS

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

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TORONTO:

Printed and Published by L. K. CAMERON, Printer to the King's Most Excellent Majesty

1905

WARWICK BRO'S & RUTTER, Limited, Printers,
Toronto.

CONTENTS

LIST OF ILLUSTRATIONS.

To His Honor William Mortimer Clark, Etc., Etc., Etc.,

Lieutenant-Governor of the Province of Ontario.

Sir,—I have the honor to transmit herewith for presentation to the Legislative Assembly, the Fourteenth Report of the Bureau of Mines.

I have the honor to be, Sir,

Your obedient servant,

J. J. Foy,

Commissioner of Crown Lands.

Department of Crown Lands,

Toronto, 6th April, 1905.

To the Honorable James Joseph Foy,

Commissioner of Crown Lands.

Sir,—I beg to submit to you herewith, to be presented to His Honor the Lieutenant-Governor, the Fourteenth Annual Report of the Bureau of Mines.

The Report consists of three parts, which are printed separately, namely:

Part I., containing statistics of the mineral production of the Province for the year 1904, reports by the Inspectors of Mines on the working mines of Western and Eastern Ontario, papers on Petroleum and Natural Gas, and the Cement Industry of the Province, reports of exploration parties on special mineral districts, and other information relating to the mineral resources and mining industries of the Province.

Part II., a description of the silver-cobalt-nickel ores of Lake Temiskaming, by Prof. W. G. Miller, Provincial Geologist, supplementary to the account published in the Bureau's Thirteenth Report.

Part III., a monograph on the Sudbury Nickel Region by Dr. A. P. Coleman, who spent the field seasons of 1902, 1903 and 1904 in the nickel district, and whose description covers the whole of that important mineral area, including both the southern and northern ranges.

All three Parts are accompanied by geological and other maps illustrating the territory and subjects dealt with.

I have the honor to be, Sir,

Your obedient servant,

Thos. W. Gibson,

Director.

Office of the Bureau of Mines,

Toronto, 5th April, 1905.

REPORT OF
THE BUREAU OF MINES
1905

Vol XIV **Part I**

By Thos. W. Gibson, Director

Statistical Review

Table I summarizes the output of the mines and metallurgical works of the Province of Ontario for the calendar year 1904. It will be seen that the total value is $11,572,647, a decrease as compared with 1903 of $1,297,946, mainly accounted for by the diminished yield of the nickel field, where one of the plants was closed for part of the year, and the other was being rebuilt on a larger and more modern scale.

Table I.—Mineral Production of Ontario 1904

Product.	Quantity.	Value.	Employees.	Wages.
Metallic:		$		$
Gold ... ounces	2,285	40,000	210	128,000
Silver ... "	206,875	111,887		
Platinum ... "	536	10,452		
Palladium ... "	952	18,564		
Cobalt ... Tons	29	36,620	1,063	570,900
Copper ... "	2,163	297,126		
Nickel ... "	4,743	1,516,747		
Iron Ore ... "	53,253	108,068	191	84,673
Pig Iron ... "	127,845	1,811,664	1,522	539,482
Steel ... "	51,002	1,188,349		
Lead Ore ... "	3,210	11,000	16	6,000
Pig Lead ... "	43	2,500		
Zinc Ore ... "	533	3,700	15	5,712
		5,156,677	3,017	1,334,767
Less value Ontario ore smelted into pig iron, Ontario pig iron converted into steel, and lead ore smelted into pig lead ...	...	250,000		
Net metallic production ...	...	4,906,677	2,807	1,334,767
Non-metallic:				
Actinolite ... tons	408	102	...	...
Arsenic ... "	72	903	...	...
Tile, drain ... number	16,000,000	210,000	3,000	660,000
Brick, common ... "	200,000,000	1,430,000		
" paving ... "	4,436,000	55,450	67	27,300
" pressed ... "	26,857,000	226,750	217	101,530
Building and crushed stone ...	...	700,000	1,440	510,186
Carbide of calcium ... tons	2,343	152,295	78	35,200
Cement, natural rock ... bbls	85,000	65,250	60	22,050
" Portland ... "	880,871	1,239,971	734	323,689
Corundum ... tons	1,665	150 645	202	139,548
Feldspar ... "	10,983	21,966	34	16,300
Graphite ... "	355	4,700	52	11,925
Gypsum ... "	5,412	10,674	14	6,000
Iron Pyrites ... "	13,451	43,716	60	22,875
Lime ... bush	2,600,000	406,800	500	150,000
Mica ... tons	332	37,847	79	21,529
Natural Gas ...	...	253,524	98	53,674
Peat Fuel ... tons	800	2,400	10	2,000
Petroleum ... Imp. gals	17,237,220	904,437	406	229,955
Pottery ...	...	100,000	100	30,000
Salt ... tons	55,877	362,621	193	84,682
Sewer Pipe ...	...	283,000	113	54,500
Talc ... tons	1,313	2,919	17	873
Total Non-Metallic production ...	...	6,665,970	7,474	2,503,816
Add Metallic production ...	...	4,906,677	3,017	1,334,767
Total production ...	...	11,572,647	10,491	3,838,583

A comparison of the foregoing table with those given in former years will disclose the fact that the mineral products of Ontario, already numerous and varied, are growing steadily in number and variety. Three metals find a place in the output of 1904 which were wanting in 1903, namely platinum, palladium and cobalt. The first two of these are new entrants, and are to be credited to the Sudbury nickel field, from the mattes of which they are obtained as bye-products. Further comment is made on these metals on a later page. The third, cobalt, does not make it first appearance in 1904, but has been absent from the list since 1894. Like the other two it is found in the nickeliferous pyrrhotite, but until last year no returns of its recovery were received at the Bureau since the Dominion Mineral Company ceased operations some ten years ago. But a much more prolific source of cobalt has been opened up in the silver-cobalt-nickel-arsenic veins of Coleman township, whose riches in silver and cobalt stamp the discovery of these deposits as one of the most important events in the history of the mining industry of Ontario, or indeed in that of the Dominion.

The following columns show clearly how this expansion in the variety of the mineral products of the Province has gone on during the 10-year period from 1895 to 1904.

Metals

	1895 $	1904 $
Silver	nil	111,887
Platinum	nil	10,452
Palladium	nil	18,564
Cobalt	nil	36,620
Iron Ore	nil	108,068
Pig Iron	nil	1,811,664
Steel	nil	1,188,349
Lead Ore	nil	11,000
Pig Lead	nil	2,500
Zinc Ore	nil	3,700

Non-Metals

Actinolite	nil	102
Arsenic	nil	903
Carbide of Calcium	nil	152,295
Corundum	nil	150,645
Feldspar	nil	21,966
Graphite	nil	4,700
Iron Pyrites	nil	43,716
Talc	nil	2,919

Thus, ten metallic and eight non-metallic substances find a place in the output of 1904 which were lacking in 1895, only some four or five of which, such as silver, cobalt, iron ore and pig iron had ever before been raised or produced in the Province.

The total number of substances combining to make up the mineral production of Ontario is thirty-seven, ten of which may be classed as construction materials. A comparison with our sister mining Provinces, Nova Scotia and British Columbia, in this respect, shows that in the official tables of the former, eleven products and in the latter, six, exclusive of the building materials, make up the list. In each case coal and gold constitute a large part of the output. This brief reference will make it plain how different are the conditions of the mining industry here from those surrounding it on the Atlantic and Pacific coasts, and will also convey some idea of the difficulties attending the endeavor to procure correct and complete statistics of the mineral production of this Province.

Table II is a comparative schedule giving the value of the several mineral products for the last five years, and enables the progress of the various departments of the industry to be traced from year to year.

Table II.—Mineral Production 1900 to 1904

Product.	1900.	1901.	1902.	1903.	1904.
	$	$	$	$	$
Metallic:					
Gold	297,861	244,443	229,828	188,036	40,000
Silver	96,367	84,830	58,000	8,949	111,887
Platinum	....	....	....	....	10,452
Palladium	....	....	....	....	18,564
Cobalt	....	....	....	....	36,620
Copper	319,681	589,080	680,283	716,726	297,126
Nickel	756,626	1,859,970	2,210,961	2,499,068	1,516,747
Iron Ore	111,805	174,428	518,445	450,099	108,068
Pig Iron	936,066	1,701,703	1,683,051	1,491,696	1,811,664
Steel	46,380	347,280	1,610,031	304,580	1,188,349
Lead Ore	....	....	....	....	11,000
Pig Lead	....	....	....	1,500	2,500
Molybdenite	....	....	400	1,275	....
Zinc Ore	500	15,000	11,500	17,000	3,700
	2,565,286	5,016,734	7,002,499	5,678,929	5,321,677
Less value Ontario ore smelted into pig iron, and pig iron converted into steel	....	....	745,000	436,354	250,000
Total metallic production	2,565,286	5,016,734	6,257,499	5,242,575	4,906,677
Non-Metallic:					
Actinolite	....	3,126	6,150	1,650	102
Arsenic	22,725	41,677	48,000	15,420	903
Brick, common	1,379,590	1,530,460	1,411,000	1,561,700	1,430,000
Brick, paving	26,950	37,000	42,000	45,288	55,450
" pressed	114,419	104,394	144,171	218,550	226,750
Building and crushed stone	650,342	850,000	1,020,000	845,000	700,000
Carbide of Calcium	60,300	168,792	89,420	144,000	152,295
Cement, natural rock	99,994	107,625	50,795	69,319	65,250
" Portland	598,021	563,255	916,221	1,182,799	1,239,971
Corundum	6,000	53,115	83,871	87,600	150,645
Feldspar	5,000	6,375	12,875	20,046	21,966
Graphite	27,030	20,000	17,868	20,636	4,700
Gypsum	18,050	13,400	19,149	7,910	10,674
Iron Pyrites	....	17,500	14,993	21,693	43,716
Lime	544,000	550,000	617,000	520,000	406,800
Mica	91,750	39,780	102,500	102,205	37,847
Natural Gas	392,823	342,183	199,238	196,535	253,524
Peat Fuel	....	....	....	3,300	2,400
Petroleum products	1,869,045	1,467,940	1,431,054	1,586,674	904,437
Pottery	157,449	193,950	171,315	160,000	100,000
Salt	324,477	323,058	344,620	388,097	362,621
Sewer pipe	130,635	147,948	191,965	199,971	283,000
Talc	5,000	1,400	930	2,625	2,919
Tile, drain	209,738	231,374	199,000	227,000	210,000
Total non-metallic production	6,733,338	6,814,352	7,134,135	7,628,018	6,665,970
Add metallic production	2,565,286	5,016,734	6,257,499	5,242,575	4,906,677
Total production	9,298,624	11,831,086	13,391,634	12,870,593	11,572,647

GOLD

Dealing briefly with the figures of the several products as given in Tables I and II, it is first to be remarked that the yield of gold has again suffered a heavy decline as compared with the previous year, when the production was smaller than in 1902. The greatest output of gold in this Province was in 1899, when it had a value of $424,568. This was when the excitement in the Lake of the Woods and Rainy Lake regions had led to the erection and operation of a large number of stamp mills to test the auriferous quartz veins of those districts. In many cases results not being up to expectations, and in others funds raised by the sale of non-assessable stock having been exhausted before the mine was placed on a paying basis, the outcome of the venture was the closing down and virtual abandonment of the property. Too often the result was brought about or hastened by the incompetency, or worse, of the management.

Bullion was produced last year in an experimental way at half-a-dozen properties on Lake of the Woods, Eagle lake and elsewhere, and on a slightly larger scale at the Sultana, Sunbeam (or A L 282) and St. Anthony Reef mines, while a good deal of

development work was carried on not only at the properties mentioned, but also at the Laurentian and Volcanic Reef mines on lake Manitou, at the Golden Horn on Rush bay, by the Northern Light Mines Company, the Camp Bay Mining Company, the Eldorado Mining Company and others.

In eastern Ontario, the only gold actually obtained was by the Cook Land Company, near Marmora. Belmont and Deloro were idle, but there are hopes of resuming work at both places. The Craig mine is being re-opened, and a new property, the Star of the East in Barrie township, is under development. For the first time returns were made of the recovery of small quantities of gold and silver from the mattes of the Sudbury nickel district. Some attention is being paid to the placer ground on the upper Vermilion river, with the view of putting a dredge at work if the gold found in the immense gravel deposits of that region is ascertained to be present in payable quantity.

The output of gold and other details of the industry for the last five years are given in the following table:

Gold Mining 1900 to 1904

Schedule	1900	1901	1902	1903	1904
Mines worked ... No.	18	11	20	19	12
Ore treated ... tons.	46,618	54,336	48,544	32,347	....
Gold product ... oz.	18,767	14,293	13,625	10,383	2,285
Gold value ... $	297,861	244,443	229,828	188,036	40,000
Men above ground ... No.	412	305	341	243	100
" under ground ... "	338	288	385	250	130
Wages paid ... $	350,694	287,409	343,984	245,490	133,000

SILVER

Hitherto, practically all of the silver produced in Ontario has come from the lake Superior region. The typical mine of this district was Silver Islet, a tiny rock lying off a bold peninsula now forming the Sibley township forest reserve, where Thomas Macfarlane in 1868 discovered silver ore rich in large nuggets and smaller disseminated particles, and whence by working with crowbars under the water he obtained the first shipment of 1,336 lb. of ore, the assay of which was 2,087 ounces Troy per long ton. From first to last about $3,500,000 worth of silver was extracted from Silver Islet mine.[1]

The rich veins of this mine and of other valuable silver mines which were opened up at a later date in the district west of Port Arthur, in an area of similar geological features, traversed the slates of the Animikie formation, and this fact is of interest in relation to the latest of the silver fields of this Province, that now being energetically developed in the township of Coleman on the Temiskaming and Northern Ontario Railway. Here the lodes occur in the slate breccia, and so far have not been found either lying in or extending downwards into any of the associated or underlying formations. It is noticeable, too, that to a marked extent the assemblage of minerals is similar, including cobalt, nickel and arsenic, though the development of these in Coleman appears to be greater than it was in Silver Islet. The veins are narrow, but exceedingly rich, and the aggregate output of the properties, from present appearances, may easily equal if not surpass in value the yield of Silver Islet, notwithstanding that the price of silver now is less than half what it was 25 or 30 years ago.

1 *See* the Story of Silver Islet Sixth Rep. B. of M. pp. 125-158. Mr. Macfarlane, one of the band of early geologists, which included also Logan, Hunt, Murray and Bell, that did such yeoman service in laying the foundations of Canadian geology, is like the last mentioned, still in harness, though having transferred his allegiance from geology to chemistry. Mr. Macfarlane now fills the position of Chief Analyst to the Department of the Interior, Ottawa.

All the silver produced in 1904 came from the mines of Coleman township, save a small quantity extracted from the Sudbury nickel-copper mattes. The output was 206,875 ounces, valued at $111,887. The producing properties were the Larose, owned by Messrs. Timmins, Dunlap and McMartin; the Chambers-Ferland properties, including Cobalt Hill and the Little Silver mine, now owned by the Nipissing Mining Company, Limited, New York, of which Mr. Ellis P. Earle is the head; the New Ontario owned by Mr. W. G. Trethewey of Toronto; and the McKinley-Darragh, of which Messrs. Gorman & Co. of Ottawa, otherwise the Cobalt and Silver Mining Company, are proprietors. The ore was all sold to Mr. E. P. Earle and delivered to him at New York. Some of the shipments carried very high values, several 20-ton carlots netting as much as $37,000 or $38,000, the main returns being from the silver, though the other constituents, cobalt, nickel and arsenic, each contributed to the result. Production has been going on at an increasing rate since the close of the year, and for the first six months of 1905 the ore shipped yielded 1,128,212 ounces of silver, valued at $595,974. Several other properties have also been opened up in 1905 from some of which shipments have been made.

The new camp enjoys first-rate shipping facilities, since the Temiskaming and Northern Ontario Railway runs directly through it, and a station called Cobalt has been established on the shore of a lake of the same name within easy distance of the chief producing properties. The freight rate from Cobalt to New York is $7 per ton.

For a fuller account of the geology and mineralogy of this interesting and important field, reference should be had to the report of Prof. W. G. Miller, Provincial Geologist, published as Part II. The geological map of the area accompanying the report was issued in advance, and has been in active demand from prospectors and others.

Considerable prospecting was done in the neighborhood of the original finds during the season of 1904, and several fresh discoveries were made, but so far no new fields of like kind have been located in the extensive regions of slate conglomerate in the neighborhood of lake Temagami and on the Montreal river. A great deal of the territory is covered by green timber, including much valuable pine, consequently prospecting must be carried on carefully, and is slow and tedious work.

Silver Mining 1900 to 1904

Schedule	1900	1901	1902	1903	1904
Ore raised....tons.	12,500	11,000	6,250	3,400	158
Ore stamped.... "	8,000	7,560	6,250	3,360	158
Bullion product.... oz.	160,612	151,400	96,666	16,688	206,875
Value of bullion.... $	96,367	84,830	58,000	8,949	111,887
Average men above ground.... No.	20	30	25	12	29
" " under ground.... "	30	35	25	20	28
Wages paid for labor.... $	24,000	29,500	36,000	8,000	12,300

PLATINUM

It has long been known that platinum occurs in association with the nickel-copper ores of the Sudbury region, mainly, it is believed, as the arsenide sperrylite, so called after Mr. F. L. Sperry, who in 1889 first isolated it from the gossan of the Vermilion mine.[2] It is also found in the ore of the Victoria, Copper Cliff and other mines of the region, varying from almost inappreciable quantities up to 3 dwt. and even over 7 dwt. per ton of ore, in proportion, apparently, to the percentage of chalcopyrite present. But the fact that platinum has been recovered from Sudbury ores as part of their commercial treatment has only recently been made public, and the successful extraction of quantities so minute is a tribute to the perfection at which modern metallur-

[2] 1st Rep. B. of M. pp. 91, 92; also 7th Rep. p. 142, 12th Rep. pp 272, 282, 283; and other references.

gical processes have arrived. By far the greater portion of the world's supply of platinum is derived from alluvial deposits, the Ural mountains in Russia being the chief source, but it is found also in New South Wales, California, British Columbia, the Yukon, and many other parts of the world, in association with placer gold. It can probably be claimed that Ontario furnishes the first instance of solid ore being regularly treated for the recovery of platinum.

The yield of this rare metal for 1904 is returned at 536 ounces, which at $19.50 per ounce, had a value of $10,452. In 1902 and 1903 the quantities obtained were considerably larger, being for the former year 2,375 ounces, and for the latter 1,710 per ounce, had a value of $10,452. In 1902 and 1903 the quantities obtained were considerably larger, being for the former year 2,375 ounces and for the latter 1,710 ounces, of the value, at the above price per ounce, of $46,312 and $33,345 respectively. The yield of platinum, therefore, from the ores of the Sudbury district for the last three years, before which little or none was obtained, was as follows:

	Quantity ounces	Value $
1902	2,375	46,312
1903	[illegible]	33,345
1904	536	10,452
Total	4,621	$90,109

The above quantities were recovered, not only from the mattes treated during the respective years, but also from the residues or accumulations of several years, so that no data exist for estimating the tonnage of the ore from which they were taken, or how much was obtained from the matte in any one year. It is stated, and no doubt correctly, that if the mattes had to be treated solely for the purpose of winning the platinum and other bye-product metals—details of the production of which are given under their respective headings—the process would be an unprofitable one, and they would not be recovered at all, but as very much of the manipulation is necessary for extracting the nickel and copper, which provide the chief values, the subsidiary metals, comprising gold, silver, platinum, palladium and cobalt, can be obtained at a profit.

The prospects of the Sudbury ores furnishing a steady supply of platinum from this time forward are however not hopeful, for the reason that until the last year or two most of the ore raised by the principal producer, the Canadian Copper Company, came from the Copper Cliff group of mines rich in copper, but somewhat less rich in nickel, while now almost the whole of the ore smelted by that Company is taken from the Creighton mine, which is unusually high in nickel, but comparatively low in copper. As the platinum appears for the most part to bear company with the copper, the yield may be expected to be small, so long as the Creighton ore continues to be exclusively used. It may be added, as illustrating the comparative scarcity of platinum, that in British Columbia, the only other Province in Canada yielding this metal, the quantity obtained last year was only 35 ounces.

PALLADIUM

Palladium is another of the rarer metals which appears on the list of Ontario productions for the first time in 1904. Its source is also in the nickeliferous pyrrhotites of Sudbury—those remarkable ores from which no less than seven different metals are obtained: nickel, copper, cobalt, gold, silver, platinum and palladium, and from which two other useful substances, one a metal and the other a non-metal, namely iron and sulphur, are eliminated only to be wasted. The announcement that palladium was being obtained by the Orford Copper Company at its New Jersey works from Sudbury matte was made by Dr. Joseph Wharton, Sc. D., LL.D., in an address delivered in April, 1904, before the American Philosophical Society, and published in Vol. XLIII of the Proceedings of that body. Dr. Wharton points out that although

palladium belongs to the platinum group of metals, it is in some respects nearly related also to silver, its atomic weight and specific gravity being respectively about 107 and 11.4, while the corresponding figures for silver are 108 and 10.5. In its high melting point, however, of 1500°C., it approaches more nearly to platinum, which melts at 1750°C., and in color its grayish-white resembles the color of platinum more nearly than that of silver. He adds:

"Palladium has long been known to occur native in company with platinum, and also alloyed with gold in the Brazilian mineral porpezite, which contains about 5 to 10 per cent. of it. That it occurs in notable quantity in the nickeliferous pyrrhotite of Canada is an important recent observation. Both platinum and palladium probably exist to a greater or less extent in all the many deposits of nickeliferous pyrrhotite throughout the world; certainly in those of Norway and Sweden, and particularly in every one of the numerous deposits of that mineral which are found in the Laurentian and Huronian rocks surrounding the little town Sudbury, in the Province of Ontario, Canada. The quantity, however, is extremely small, varying from a mere trace to one or more ounces per ton; the average for each metal being about one hundredth of an ounce per ton of ore, platinum and palladium usually being present in approximately equal parts. Yet, though known to exist in many parts of the world. palladium has not been diligently sought for, because there was until recently no considerable demand for it; the re-working of platiniferous residues from the mints of several countries having supplied most of that which appeared in commerce. The prevailing scarcity of platinum is now directing attention to palladium as a practicable substitute for some purposes . . . . . . The form in which palladium there [*i. e.* in the Sudbury ores] occurs has not been detected, for owing to its minute quantity and the consequent difficulty of isolating it, none has yet been directly observed in any ore of that region; since, however, platinum occurs there as arsenide in the interesting mineral sperrylite ($PtAs2$), palladium may exist in similar combination, though none has been observed in any specimen of sperrylite that has been examined"

The uses of palladium are enumerated by Dr. Wharton as follows:

"1. For the mechanism of delicate instruments, such as chronometers, and for verniers, etc., of astronomical instruments.

"2. For surgical instruments.

"3. For plating searchlight mirrors. Why not for the mirrors of reflecting telescopes?

"4. For alloying with silver to make dental plates, etc., instead of the two-thirds silver one-third platinum hitherto used in Europe. Also as palladium amalagam for fillings in cavities of teeth.

"Other uses will naturally arise as men's minds are turned toward this metal which, while in many respects equal to platinum, sells for no more than the price by weight of that metal, and of course therefore for much less than that by bulk; the specific gravity of platinum being variously stated as 17 to 19, and that of palladium as 11.4 to 11.8. It would seem that palladium might be useful under some circumstances for resistance wire."

An interesting general description of the method of obtaining palladium from the matte is given by Dr. Wharton, though, as he states, he purposely refrains from giving all details of the various stages of the process. He says:

"The concentrated matte is treated for separation of copper from nickel, which is effected by repeated melting with nitre cake and coke in cupola furnaces. The coke converts the nitre cake into sodium sulphide; when the charge is run out of the furnace and cooled it separates easily into two parts, the bottoms containing practically all the nickel, the tops consisting of sodium sulphide and copper sulphide; the gold and silver going with the tops, the platinum-group metals going with the bottoms. In the refining processes that follow, palladium is obtained as a slime, carrying about a thousand times as much palladium proportionally as did the original ore, carrying also the other platinum-group metals, and the gold and silver. This palladium-bearing slime is melted and refined in a small reverberatory furnace, from which it is ladled out into cold water, forming shot which are charged into small leaden towers, into the top of which hot dilute sulphuric acid is run. Palladium and the other precious metals being electro-negative to the base metals, a galvanic action now takes place in which nickel, copper and iron dissolve rapidly, leaving palladium in a black mud containing two per cent. or more of that metal. If this residue still contains much copper, that is mostly eliminated by further treatment with hot sulphuric acid until the stuff contains about 25 per cent. of palladium, when it is treated with aqua-regia, thus

dissolving all the platinum, palladium and gold. From this solution platinum is precipitated by ammonium chloride. The palladium in the filtrate is electrolytically precipitated with a platinum anode, appearing as a dull gray metal which is hard and brittle, peeling off easily from the cathode. It is then dried and ignited in a reducing atmosphere, when it takes great brilliancy and becomes very soft and pliable, capable of being worked into any ordinary form. I have, for instance, a remarkably nice teaspoon made of it."

In further exposition of the properties of palladium, Dr. Wharton asserts that besides having so very high a melting point, and being at the same time both hard, ductile and malleable, palladium is so absolutely non-corrodible that a sheet of it may hang for a long time in a laboratory exposed to chlorine and hydrogen-sulphide gases without losing its polish or being tarnished. He also comments upon its wonderful power of occluding hydrogen gas, being capable of absorbing as much as 1,030 volumes, at which point complete saturation is probably reached. In the occlusion of hydrogen, palladium exhibits its affiinity to platinum, which possesses a similar property, but in a less degree.

Regarding the quantity of palladium produced, Dr. Wharton states that there is now a steady production by the Orford Copper Company of more than 3,000 ounces annually, from approximately 300,000 tons of Canadian ores treated. According to the returns made to this Bureau, the production for 1904 was on a much smaller scale, being 952 ounces, which valued at $19.50 per ounce, the same price as for platinum, was worth $18,564. During 1902 and 1903, however, the output exceeded Dr. Wharton's figures, as shown in the following table:

	Quantity ounces	Value $
1902	4,411	86,014
1903	3,177	61,952
1904	952	18,564
Total	8,540	$166,530

Palladium as well as platinum is found in British Columbia, the report of the Consolidated Cariboo Hydraulic Mining Company, Limited, for 1904, showing that the heavy concentrates remaining in the sluices after cleaning up yielded on analysis 61.4 ounces of palladium per ton, as well as 64 ounces of platinum and 42 ounces of osmiridium. The platinum, palladium and osmiridium were found as minute metallic grains and enclosed in small fragments and nuggets of magnetite and chromite. The gold, silver and copper contents of these concentrates brought the total value up to $5,993.56 per ton.[3]

COBALT

As already stated, the last production of cobalt from Ontario ores reported to the Bureau previous to 1904 was in 1894, when some 3¼ tons were returned, valued at $1,500. Inclusive of 1894 the total output up to that time appears to have been 30¾ tons, worth $14,613. In 1904 the yield was 29 tons, worth $36,620. This came from two sources: (1) the nickel-bearing ores of the Sudbury region, and (2) the silver-cobalt-nickel-arsenides of Coleman township, already referred to under the heading of silver, the latter producing a little more than half. As in the case of platinum and palladium, cobalt has been obtained in refining the Sudbury mattes for the last three years, the total quantity obtained in this time being a little over 32 tons. The material treated during this period consisted for the most part of the concentrated matte made at the Ontario Smelting Works by crushing, calcining and re-smelting the ordinary or low-grade mattes produced at the Copper Cliff smelters, and doubtless residues from mattes of the same kind previously treated for nickel and copper. In re-modelling and modernizing the smelting works at Copper Cliff after the Ontario plant was destroyed by fire, Bessemer converters were substituted for the Brown calciners, and

[3] Company's Seventh Annual Report, published in The Mining Record, Victoria, B.C., March, 1905.

in the process of converting the low-grade into high-grade matte in the Bessemer converters, practically all of the cobalt is blown out and wasted; since this metal oxidizes in the early stages of the blowing process, along with the iron, leaving the nickel and copper in the matte. As both the Canadian Copper Company and the Mond Nickel Company now produce Bessemer matte exclusively, the production of cobalt from the Sudbury ores is likely, for the time being at least, to cease. The fact that the cobalt is lost in the Bessemer process does not prove that process to be an uneconomical one, since its other advantages from a monetary point of view are more than sufficient to counterbalance the loss in this respect.

The extinction of this source of supply of cobalt, however, by no means implies the disappearance of cobalt from the list of minerals produced in Ontario. Indeed, the new resources of this metal now being exploited in Coleman township are of much greater extent and value as a source of cobalt than the pyrrhotites of Sudbury, in which it is present in small percentages only. The ores of Coleman are no doubt the richest ores of cobalt now being mined anywhere, containing as they do up to 18 per cent. of the metal. Shipments from Cobalt station during the first six months of 1905 contained a total of 65 tons of cobalt, valued at $80,560. The gross weight of the ore was 891 tons, the average cobalt contents being thus 7.3 per cent.

It is not a little curious—yet considering the natural affinities of the two metals, not surprising—that as Ontario has wrested the supremacy from the island colony of New Caledonia in the production of nickel, so also is it now bidding fair to accomplish the same result in the production of cobalt. In fact, it may almost be said that it has already done so, since the price of cobalt which in the Bulletin du Commerce, published in Noumea, New Caledonia, was quoted in October, 1904, at 150 to 160 francs per ton (2,240 lb.) for ore containing 4 per cent. cobalt, had in March 1905, after regular shipments from the Coleman veins had begun, fallen to 100 to 125 francs. Nor is this to be wondered at, when the ores are compared, the New Caledonia product carrying 4 or 5 per cent. cobalt and the Ontario ore 16 or 18 per cent., to say nothing of the other constituents, silver, nickel and arsenic. The price which the cobalt miners in Coleman receive for their output in New York is about 65 cents per lb. of cobalt contents, or say $195 per ton (2,000 lb.) of 15 per cent. ore, which compares with $29 per ton for 4 per cent. ore in New Caledonia in October, 1904, or $22 in March, 1905.

There is no guarantee, of course, beyond existing contracts, that these prices for Ontario ore will be maintained. The demand for cobalt is a limited one, which only new uses for the metal or its compounds can materially extend; and should there be a greater production at any time than the market can absorb, the result must be that prices will fall. Fortunately for the mine-owners of Coleman, the majority of the deposits are worked chiefly for their silver contents, cobalt being largely a bye-product, consequently this metal could sustain a severe fall in price without materially affecting the prosperity of the camp or the value of the mines. There are, however, one or two deposits which yield cobalt with little or no silver.

The working properties during 1904 are the same as those enumerated under the heading of Silver, and for greater detail the reader is referred to the report of the Provincial Geologist.

NICKEL AND COPPER

As compared with 1903 the output of nickel was less in quantity by 2,255 tons, and in value by $982,321. The falling off has been already explained as being due to the partial cessation of production by the Canadian Copper Company, whose new smelting plant was finished and put in operation during the year, and to the suspension of the treatment of their own ores by the Mond Nickel Company. The latter's Bessemer converters were in use part of the year by the Canadian Copper

Company for concentrating the low-grade mattes made at Copper Cliff. The Creighton nickel mine continues to produce from its open-cast workings most if not all of the ore smelted at Copper Cliff, the ease with which it can be mined and its high contents of nickel having for the present put all the Company's other deposits in the background. The quantity of ore exposed and in sight at the Creighton mine is estimated as equal to 20 or 25 years' supply at the present rate of extraction, which is not far from 1,000 tons per day. From the several mines owned by this company there were raised during 1904 the following quantities of ore:

	Tons
Copper Cliff	14,713
No. 2	336
Creighton	169,911
Total	184,960

The Mond Nickel Company, whose works are situated at Victoria Mines, smelted no ore last year, but raised 5,935 tons from their Victoria No. 1 mine, and 12,493 tons from the North Star, a property recently acquired from Mr. A. McCharles of Sudbury. This company is making arrangements to re-open its mines and works.

None of the other companies or firms interested in the Sudbury nickel district engaged in active business last year, and it seems as if other concerns were chary of entering into competition with those already established in the field. Mr. Thomas A. Edison, the famous electrician and inventor, whose experts prospected the nickel belt with magnetic instruments in the hope of locating hidden or underground bodies of ore, has not, so far as known, met with great success, but it is understood there is a likelihood of his re-entering the field and resuming operations. The northern nickel range, owing to lack of railway facilities, has not yet become the scene of actual mining. Should a line be built from Sudbury or some other point on the Canadian Pacific across the northern range to the iron ore bodies in Hutton township, it would probably give life and activity to both these regions, whose resources will continue to lie dormant until that day arrives. Neither nickel nor iron mines can be opened up or worked unless served by a railway.

One feature which marks the development of industrial activity in the nickel region is the use which is beginning to be made of the water powers with which it has been by nature lavishly endowed. For instance, on the Vermilion river in Creighton township, at High falls on the Spanish near Turbine station, and in Dryden township on the Wahnapitae, three separate water power developments are in progress at the present time, each on a considerable scale, the first and last with a view to supplying the towns, villages and mines with cheaper power than can at present be obtained by the use of steam, and also no doubt in the hope of assisting to locate in the neighborhood industrial enterprises requiring considerable motive energy, such as pulp and paper mills, woodworking establishments, etc. The privilege on the Spanish river is being improved by the Canadian Copper Company for supplying power to operate its mines, provide electric lighting, etc. Now that the electrical transmission of energy generated by falling water has so immensely increased the usefulness of water powers by lengthening the radius within which they can be used, it may be expected that similar developments will take place in many other parts of northern Ontario, in which water powers, large and small, are numerous.

The quantity of nickel contained in the silver-cobalt-nickel ores of Coleman township shipped during the year was 14 tons.

The following table gives statistics of nickel and copper production for the past year, and for the sake of comparison, similar details for the four preceding years:

Nickel-Copper Mining 1900 to 1904

Schedule		1900	1901	1902	1903	1904
Ore raised	tons.	216,695	326,945	269,538	152,940	203,388
Ore smelted	"	211,960	270,380	233,388	220,937	102,844
Ordinary matte produced	"	23,336	29,588	24,691	30,416	19,123
High grade matte produced	"	112	15,546	13,332	14,419	6,926
Nickel contents	"	3,540	4,441	5,945	6,998	4,743
Copper contents	"	3,364	4,197	4,066	4,005	2,163
Value of Nickel	$	756,626	1,859,970	2,210,961	2,499,068	1,516,747
Value of Copper	"	319,681	589,080	616,763	583,646	297,126
Wages paid	"	728,946	1,045,889	835,050	746,147	570,901
Men employed	No.	1,444	2,284	1,445	1,277	1,063

The quality of the Creighton ore is reflected in the figures given above, which show that the ore smelted contained an average of 4.58 per cent. of nickel, which is 1.42 per cent. in excess of the average contents of the ore treated in 1903. In fact ever since the rich product of the Creighton mine has begun to be used by the Canadian Copper Company, the average nickel contents of the ore have appreciably risen. Thus, while in 1901 the ore contained on an average 1.64 per cent. nickel, in 1902 it carried 2.54 per cent., in 1903 3.16 per cent., and in 1904, when virtually only Creighton ore was used, 4.58 per cent.

The values given in the foregoing table are based on the selling prices of nickel and copper in the matte, in which form the metals are exported for refining in the United States and Great Britain.

The productive copper mines of Ontario are the deposits of the Sudbury region, worked for nickel as the chief object of quest, though at the first it was the chalcopyrite showings at the surface that attracted attention. The purely copper ore bodies, situated mainly on the north shore of lake Huron, of which the once famous Bruce mines is the best known example, are in the aggregate important, and will doubtless in time contribute more largely to the output than they do at present. The Massey and Hermina mines, near Massey Station on the Sault Ste. Marie branch of the Canadian Pacific Railway, the Superior mine near Sault Ste. Marie, and the Tip-top mine west of Port Arthur are all on sulphide deposits. The first mentioned has been systematically developed, and its workings are now fairly extensive. An Elmore oil concentrating plant was installed at the Massey mine last year, the first in Ontario, if not in Canada, and the results of its operation are said to be satisfactory. It is claimed for the Elmore process that it is peculiarly suited to the saving of finely disseminated copper sulphides such as characterize the Massey mine. The output of the non-nickeliferous copper mines in 1904, as returned to the Bureau of Mines, was not large, amounting to some 2,700 tons of ore containing about 121 tons of copper. These figures, as well as those of other details of production, are included in the table given above.

The copper contents of the nickel-copper ores smelted in 1904 averaged 1.86 per cent., thus evidencing the fact that the ore of the Creighton mine is much less rich in copper than in nickel.

IRON ORE

Shipments from the iron mines of the Province in 1904 amounted to 128,253 tons, but as some 75,000 tons of this were included in the returns of 1903 as having been mined in that year, the net product must be set down as 53,253 tons, compared with an output of 208,154 tons raised in 1903. As the chief working property is the Helen mine in Michipicoten, the production of iron ore fluctuates with the fortunes of the Helen. In 1903 the troubles which overwhelmed the allied companies at Sault Ste. Marie closed the mine before the end of the season of navigation, and although

it was kept dry, pending the re-organization of the business, raising ore was not resumed until 14th July of last year. The ore shipped was consigned to Cleveland and Point Edward, cargoes for the former port amounting to 77,390 tons being for M. Hanna and Company, and the Point Edward shipments for the Hamilton Steel and Iron Company, Hamilton, Ont. The prospects for a large yield from the Helen during 1905 are excellent, since it is now being worked vigorously, and is turning out ore at the rate of 1,000 tons per day. Recent examinations show that the ore body 180 feet below the old level of Boyer lake seems to be as large as ever, and the ore of as high a grade. A shaft 120 feet lower will give access to ore nearly 400 feet below the top of the original ore body.

A small quantity of hematite was got out at the Williams iron mine, in the township of Deroche, part of which was shipped to the blast furnace at Sault Ste. Marie. The quantity guaranteed by the shippers is a minimum of 50 per cent. iron (in natural condition of ore), and a maximum contents of 0.03 per cent. phosphorus, and 0.05 per cent. sulphur. About 6 to 10 per cent. of this ore can be used in the blast furnace for Bessemer pig.

The only other productive mine last year was the Radnor, near Eganville, the property of the Canada Iron Furnace Company. This yields a magnetic ore which is used by the company to mix with the bog ores smelted in their Quebec furnaces.

The quest for iron ores still continues. At Loon lake, east of Port Arthur, diamond drill borings and other tests have been carried on and there seems now to be little doubt that the hematite deposits of this region will prove of very considerable value, notwithstanding the fact that a proportion of the ore is not high in metallic iron. On the banded outcroppings of magnetite on the northeast arm of lake Temagami a diamond drill was expected to obtain evidence regarding the character of the deposit in depth, but unforeseen difficulties were encountered during the progress of the work which have caused it to be suspended. First, a very strong flow of artesian water was struck, and when after much labor this was got under control, the drill entered a seam of extremely hard gravel or fragments of rock, in which the bit revolved without making any headway. It is to be hoped further development work will be undertaken at an early date, so as to demonstrate whether the range contains bodies of concentrated ore, or whether the surface conditions persist at depth. In the latter case the aggregate quantity of ore will still be very large, but it will contain so high a proportion of silica as to render artificial concentration necessary. Some of the processes of magnetic concentration in vogue in the United States or elsewhere could no doubt be applied with success.

There are indications of a new hematite field on the western shore of lake Temiskaming, between the villages of Haileybury and New Liskeard, where outcroppings occur not far from the water's edge. Some miles to the west fragments of iron formation may be seen, and altogether the conditions are such as to afford color to the conjecture that a buried range may exist overlaid not only by the Niagara limestones, but also by a heavy burden of clay. A diamond drill would be the best implement for setting the question at rest.

The Hutton range has remained untouched throughout the year, and will probably continue quiescent until the advent of a railway enables machinery to be taken in to open it up and provide the means for transporting the ore to market.

The deposits of magnetic ore on the Atik-okan river and near the Canadian Northern railway station of the same name are likely to form the scene of active operations if the intentions of the parties composing the Atikokan Iron Company, of which a brief statement is given below, are carried into effect.

The account of the explorations carried on last year for the Bureau of Mines by Dr. James M. Bell, in the iron ranges of Michipicoten will be read with interest, as showing that there is much ground in that district yet to be carefully looked over before it can be assumed that all the workable deposits have been located.

A brief paper on the Boston iron range, situated in the township of that name, which lies in the Temiskaming district near the height of land, gives the results of an examination of the tract made by the Provincial Geologist last year.

PIG IRON and STEEL

There was produced in the blast furnaces of Ontario last year a total of 127,845 tons of pig iron, valued at $1,811,664, a considerable increase over the output of 1903, which was 87,004 tons, worth $1,491,696. Of charcoal iron the quantity made was 10,462 tons, having a value of $140,112, the remainder, 117,383 tons, being coke iron worth $1,671,552. The average value of the charcoal iron produced was returned as $13.39 per ton and of coke iron as $14.24 per ton, (2,000 lb.), which is a decided reduction from the prices of 1903, namely $15.46 and $17.40 per ton respectively.

The ore smelted to produce the above quantity of pig iron was 223,605 tons, of which 50,423 tons were raised from mines in Ontario, and 173,182 tons imported from the United States.

The number of blast furnaces in operation during 1904 was four, as compared with three in 1903, the increase being due to the blowing in of one of the coke furnaces of the Algoma Steel Company, Limited, at Sault Ste. Marie.

A project has been launched for the erection of a blast furnace at Port Arthur by the Atik-okan Iron Company, with the view of utilizing the magnetic ores of the Atik-okan range, and also of exporting the surplus mined from these deposits to furnaces in the United States and Canada. The nominal capital of the Company is $1,000,000, and the money for purchasing the mines and erecting the furnace is to be provided by issuing bonds to the extent of $1,000,000, of which Messrs. Mackenzie, Mann and Company are to take $400,000 worth, the town of Port Arthur, by way of assisting the enterprise, $300,000 worth, and a group of American capitalists composed of Messrs. J. C. Hunter, Duluth,and De C. O'Grady and Stamford White of Chicago, the remainder. Messrs. Mackenzie, Mann and Company have taken an active part in promoting the company, their object being to bring about the development of the iron ore resources of the territory in question, as well as to provide traffic for the Canadian Northern railway. The furnace is to have a capacity of 100 tons of pig iron per day, there is to be an ore-roasting plant capable of treating 300 tons of pig per day, and ovens for making coke. The officers of the company are D. D. Mann, president, J. C. Hunter, vice-president, R. M. Hunter, secretary, H. Sutherland, treasurer. The head office is at Toronto. The municipalities of Port Arthur and Fort William have agreed to provide a free site for the erection of the plant, with exemption from taxation.

Connected with the enterprise is the Canadian Coal and Ore Dock Company in which Messrs. Mackenzie, Mann and Company are interested, and in which they have associated with them certain coal operators of Pittsburg, Pennsylvania. Docks for loading ore and unloading coal are to be constructed, and it is expected that the facilities provided will do much to promote the welfare both of the iron and coal industries of this part of the Province.

There can be no doubt that a very large market for pig iron and for manufactures of iron and steel in every possible form is opening up on the prairies of the Northwest and in the bush lands of northern Ontario. For the making of iron and steel destined to supply these markets, it is surely more economical to bring the coal from lake Erie ports to lake Superior than to ship the ore from lake Superior to the shores of lake Erie, convert it into pig iron or manufactured goods and then pay freight on these back again over the same route previously traversed by the ore. It is reasonable to suppose that the line of least resistance will be found to exist in this direction, and that notwithstanding the long established customs and course of trade, there is a future ahead for an iron making and iron working industry established at the head of navigation on the western shores of lake Superior.

The steel made by the Hamilton Steel and Iron Company and The Algoma Steel Company together amounted to 51,002 tons, valued at $1,188,349. Open-hearth steel for various uses is produced by the former, while the output of the latter consisted wholly of steel rails.

The statistics of the pig iron and steel manufacture for 1904 are as follows:

Ontario ore smelted....	tons	50,423
Foreign " "	"	173,182
Scale and Mill cinder....	"	12,776
Limestone for flux....	"	61,566
Coke for fuel....	"	135,108
Value of fuel....	$	677,138
Charcoal for fuel....	bush	1,821,270
Value of fuel........	$	72,851
Pig iron product....	tons	127,845
Value of product....	$	1,811,664
Steel product....	tons	51,002
Value of product....	$	1,188,349
Workmen employed....	No.	1,522
Wages paid....	$	539,482

The following table gives details of the iron and steel making industry of the Province for the last five years:

Production Iron and Steel 1900 to 1904

Schedule.		1900.	1901.	1902.	1903.	1904.
Ontario ore smelted...........................	tons.	22,887	109,109	92,883	48,092	50,423
Foreign ore smelted...........................	"	77,805	85,401	94,079	103,137	173,182
Limestone flux................................	"	24,927	51,452	58,885	49,426	61,566
Coke..	"	59,345	113,119	111,390	96,540	135,108
Charcoal......................................	bush.	955,437	915,789	968,623	932,630	1,821,270
Pig iron......................................	tons.	62,386	116,370	112,687	87,004	127,845
Value pig iron................................	$	936,066	1.701,703	1,683,051	1,491,696	1,811,664
Steel...	tons.	2,819	14,471	68,802	15,229	51,002
Value...	$	46,380	347,280	1,610,031	304,580	1,188,349

The Iron Mining Fund, consisting of a sum of $125,000 originally set aside by the Legislature in 1894, to encourage the production of iron ore and pig iron in Ontario, out of which $109,741.01 had been earned up to 31 October, 1903, was exhausted by payment of the bounties earned during the year ending 31 October, 1904. The provisions of the law were such that no more than $25,000 could be paid out in any one year at the maximum rate of $1 per ton of pig iron produced, and that if more ore were raised and smelted than could be paid for out of $25,000 at $1 per ton of pig metal, the rate of bounty should suffer a proportionate reduction. The quantity of pig iron smelted from Ontario ore eligible for bounty during the 12 months ending with October, 1904, being 50,715 tons, 331 lb., and the amount available for payment of bounty thereon being $15,236.19, the rate per ton of pig iron was $0.551. The following figures give details of the payments.

Name.	Tons Ontario ore smelted.	Tons pig iron produced.	Bounty.
			$ c.
Canada Iron Furnace Co, Ltd., Midland	11,676	5,877	3,238 75
Hamilton Steel and Iron Co. Hamilton	39,039	21,771	11,997 44
Total	50,715	27,648	15,236 19

No provision having been made by the Legislature for the renewal or extension of this system of assistance to the iron ore and pig iron industry, the Iron Mining Fund has become a thing of the past.

The following table shows how the total sum of $125,000 has been expended.

Bounty on Iron Ore 1896 to 1904.

Year.	Pig iron product Ontario ore. Tons.	Bounty paid. $
1896	4,000 00	4,000 00
1897	2,603 95	2,603 95
1898	8,647 19	8,647 19
1899	12,752 07	12,752 07
1900	6,737 80	6,737 80
1901	55,214 00	25,000 00
1902	53,868 22	25,000 00
1903	26,699 28	25,000 00
1904	50,715 17	15,236 19
Sundry expenses		22 80
Total	221,237 68	125,000 00

LEAD

The Ontario Mining and Smelting Company are continuing to develop the Hollandia lead mine, near Banockburn, in the county of Hastings, and last year reported an output of 3,210 tons of ore, of which a sufficient quantity was smelted in the company's own plant to produce 43 tons of pig lead, valued at $2,500.

ZINC

The Olden zinc mine near Long lake in the county of Frontenac, was under development last year, and some 533 tons of ore worth $3,700 were extracted. A deposit of some promise is under development near Wolf River, east of Port Arthur.

BUILDING MATERIALS

Under this heading may be grouped stone, lime and brick. Cement is also an important construction material, but it will be more convenient to deal with it in a separate paragraph.

Stone

The quarries of Ontario produced during 1904 a quantity of stone used largely for building purposes but also for road making, concrete work, etc. Much the larger part was derived from the limestone formations of varying age and composition, so plentifully developed in southern Ontario; to a smaller extent the sandstones, such as those of the Medina and Potsdam formations, and the granite, gneiss and trap of Archean age, were also drawn upon. A full account of the limestones of the Province by Prof. W. G. Miller, Provincial Geologist, will be found in Part II of the Bureau's Thirteenth Report, where their distribution, uses, composition, etc., are dealt with. Similar work remains to be done in connection with the sandstones of the Province, but especially with the granites, gneisses and traps of northern and eastern Ontario which occur in inexhaustible quantity and great variety.

It is passing strange that in a country so well provided with granite as Ontario, conveniently situated, too, as much of it is for shipment by water, practically none of the native material is made use of by our stone-cutters or monument-makers. Very much of the polished granite seen in our cemeteries and adorning the fronts of business blocks is turned out of the stone yards of Aberdeen, Scotland, but is really brought in the rough to that place by sea from Sweden and Norway. What Scandinavia does not furnish us, via Scotland, is sent by Massachusetts, Vermont and Quebec, but one will look almost in vain for shaft or pillar for which a domestic origin can be claimed. Surface fissures and seams have discouraged some of the attempts made to

open up granite quarries in the north, and trade customs and fashions once established are hard to change, but it seems reasonable to suppose that among the hundreds, if not thousands, of conveniently situated beds of granite and gneiss in Ontario, hand specimens of which when polished present a wealth and play of color not inferior to the imported article, suitable sites might be selected which capital and skill could convert into remunerative and abundant sources of first-class material.

The tendency, noted in the last Report, to the extinction of small quarries and the absorption of the trade by large and well-appointed works, continues unabated. Apparently, for anything except local and transient use, the day of the small quarry is nearly over.

Lime

The same prevalence of limestone which provides a plentiful supply of building stone in so many parts of the Province, guarantees an equally abundant supply of lime—an article whose usefulness is by no means confined to building purposes. There was a fairly active demand for lime last year, notwithstanding that the returns made to the Bureau indicate a somewhat lessened production as compared with 1905. The average price per bushel advanced slightly over that of the previous year, being 15.6 cents, as compared with 15.3 cents. In lime-making, as in stone-quarrying, the small producer is fast dropping out of competition with his better-equipped rivals who produce on a large scale and are possessed of modern and economical plants.

Brick

The returns of brick made in Ontario point to a smaller production in 1904 than in 1903. The unusually active demand not only in Toronto, where building was very brisk and a large burned-over area had to be rebuilt, but in practically all the cities and towns of the Province, led to a material advance in price, the average cost of bricks at the yard, which in 1902 was $6.41, and in 1903 $6.78 per thousand, having risen in 1904 to $7.15 per thousand.

Slightly larger quantities of pressed brick and paving brick were made last year in comparison with 1903. For better-class houses in the cities, fronts, etc., pressed (or rather re-pressed) brick is in good demand at considerably higher prices than are paid for common brick. The use of vitrified brick for street pavements has not extended so rapidly as was anticipated some years ago. The principal objections are two, (1) the noisiness of the pavement, and (2) the difficulty of obtaining brick possessing the necessary wear-resisting qualities.

Other manufactures of clay are sewer pipe, drain tile and pottery. Of the former $283,000 worth was made last year—a considerable advance over 1903, when the output was valued at $199,971—and pottery, which aggregated about $100,000 in value, as compared with $160,000 in the previous year.

Sewer pipe is made at Toronto and Hamilton, and another company is being organized to utilize the shales of the Medina formation, outcropping on the Credit river, in the manufacture of the same article. Notwithstanding the increase in the home product, sewer pipe continues to be brought into the country in considerable quantity.

Drain tile is made to the value of about $200,000 annually, the output for 1904 being $210,000. It is produced principally in the southern and southwestern portions of the Province, in localities where farming is most advanced, and especially where the low-lying nature of the land requires ample facilities for speedily ridding the soil of superfluous precipitation. For the most part drain tile is made in brick factories, but occasionally a business is carried on for the manufacture of tile only.

The class of pottery made from the domestic clays of this Province is of the commonest kind, such as flower pots, jardinieres, etc. Better goods are manufactured to some extent, but for such purposes the clay is imported, mainly from New Jersey.

If clays or shales of the requisite quality can be found in Ontario, large industries could be built up in the manufacture of china and tableware, as well as fire-brick and other refractory goods. To be adapted for such uses, clay must be characterized by an absence, or at any rate a minimum of fluxing ingredients, such as lime, potash, soda, iron, etc. The prevalence of limestone and lime-bearing rocks in this Province, and the absence of the Carboniferous series with its accompanying seams of fire-clay do not provide the best conditions for the occurrence of clay or shale beds of the right kind, while the severe scouring to which the rock formations have been subjected in glacial times explains the lack of residual clay deposits found in countries where ice action has been less energetic. It is known, however, that clay beds of refractory or semi-refractory character, and also of kaolin, apparently suitable for making china and porcelain, are found on the Abitibi and other rivers of the northern slope, more or less associated with deposits of lignite. The construction of the Grand Trunk Pacific and extension of the Temiskaming and Northern Ontario railways will make these regions more accessible, but careful search nearer civilization is warranted in the hope that local deposits may be found capable of supplying the raw materials for what would in all probability become a thriving industry.

The important place which clay and shale occupy in the industrial arts is perhaps not generally or fully recognized. A bed of shale or a bank of clay makes no such appeal to the imagination as does a gold or silver mine, and indeed there are not a few people by whom the title "mineral" as applied to either clay or shale would not at first be admitted. Yet in Ontario, as in many other countries, the goods manufactured from clay surpass in value many times the combined output of gold and silver. For example, the united value of the articles made of clay in this Province last year, including bricks of all kinds, tile drain, pottery and sewer pipe, was $2,305,200, while of gold and silver the yield was only worth $151,887. If a proportion of the cement product, in which clay is also an important ingredient, were included, the balance in favor clay manufactures would be still greater. Undoubtedly the chief element of value in such goods is the labor expended in producing them, but they cannot be made unless the raw materials of the proper quality exist.

In view of the great importance of the various industries which employ clay as their raw material, the Bureau of Mines has set about making an investigation of the clay and shale resources of the Province in the hope of collecting data that will be of service to those engaged in these industries, and may perhaps lead to an enlargement of the uses to which the wealth of clay and shale in Ontario may profitably be applied. This work will be under the supervision of Prof. Miller, the Provincial Geologist, who will be assisted by Mr. M. B. Baker, and it is hoped to complete it during the field season of 1905.

CEMENT

The cement made in Ontario is of two kinds, (1) Natural rock, and (2) Portland.

The manufacture of natural rock cement is not increasing, this article being less highly regarded than Portland cement, notwithstanding that for many purposes it is an efficient and satisfactory substitute. The production in 1904 as reported to the Bureau was 85,000 barrels worth $65,250, comparing with 89,549 barrels in 1903 worth $69,319. The average selling price at the factories remained the same as last year, namely 77 cents per barrel.

In the Portland cement industry the expansion commented on in previous reports continued during 1904, the production rising in quantity from 695,260 barrels in 1903 to 880,871 barrels in 1904, and in value from $1,182,799 to $1,239,971, the rate of increase as measured by output being 26 per cent. The price however, fell off considerably, averaging at the works $1.40 per barrel as against $1.70 in 1903. The number

of producing companies last year was nine, the Ontario Portland Cement Company's plant at Blue lake, near Brantford, having begun production during the year. Other factories in various stages of completion when the year closed were those of the Belleville Portland Cement Company, Belleville, the Western Ontario Portland Cement Company, Atwood, and the Colonial Cement Company, Wiarton. The Raven Lake Cement Company, Raven lake, went into operation just at the end of 1904. It is unnecessary to make further comment on the Portland cement industry of Ontario here, since in the present volume a detailed report upon it by Mr. P. Gillespie will be found.

The progress of both branches of cement-making in Ontario since 1891 is set out in the subjoined table.

Production of Ccment 1891 to 1904

Year.	Natural rock.		Portland.		Total.	
	bbl.	value. $	bbl.	value. $	bbl.	value. $
1891	46,178	39,419	2,033	5,082	48,211	44,501
1892	54,155	38,580	20,247	47,417	74,402	85,997
1893	74,353	63,567	31,924	63,848	106,277	127,415
1894	55,323	48,774	30,580	61,060	85,903	109,834
1895	55,219	45,145	58,699	114,332	113,918	159,477
1896	60,705	44,100	77,760	138,230	138,465	182,330
1897	84,670	76,123	96,825	170,302	181,495	246,425
1898	91,528	74,222	153,348	302,096	244,876	376,318
1899	139,487	117,039	222,550	444,227	362,037	561,266
1900	125,428	99,994	306,726	598,021	432,154	698,015
1901	138,628	107,625	350,660	563,255	489,288	670,880
1902	77,300	50,795	522,899	916,221	609,199	967,016
1903	89,549	69,319	695,260	1,182,799	784,809	1,222,118
1904	85,000	65,250	880,871	1,239,971	965,871	1,305,221

The number of persons employed in making natural rock cement was 60, and the amount paid out in wages $22,050; and in Portland cement 734 and $323,689 respectively.

CALCIUM CARBIDE

There are two plants engaged in the manufacture of calcium carbide, the Ottawa Carbide Company at Ottawa, and the Willson Carbide Company at Merritton. Their combined output for 1904 was 2,343 tons valued at $152,295, as compared with 2,507 tons worth $144,000 in 1903. The slight falling off in production was thus accompanied by a rise in the price per ton from $57.43 to $65.

The following table gives details of the industry for the last five years:

Calcium Carbide 1900 to 1904

Schedule.	1900.	1901.	1902.	1903.	1904.
Carbide produced .... tons	1,005	2,771	1,402	2,507	2,343
Value of product .... $	60,300	168,792	89,420	144,000	152,295
Workmen employed .... No.	32	83	57	66	78
Wages paid .... $	72,584	40,788	28,965	33,934	35,200

CORUNDUM

The quantity of grain corundum produced from the deposits of Raglan and Carlow townships, in the counties of Renfrew and Hastings respectively, during 1904, was 1,665 tons valued at $150,645, compared with 1,119 tons worth $87,600 in 1903. The

producing companies continue two in number, namely, the Canada Corundum Company, and the Ashland Emery and Corundum Company, formerly the Ontario Corundum Company. The mines and works of the former are situated at Craigmont in the township of Raglan, and of the latter at New Carlow in the township of Carlow, which adjoins Raglan. Corundum Refiners, Limited, mentioned in the report for last year, have not yet begun production.

Statistics of the corundum business since 1900, when the first production was made, are as under:

Corundum 1900 to 1904

Schedule.	1900.	1901.	1902.	1903.	1904.
Corundum produced....................tons	60	534	1,137	1,119	1,665
Value of product.......................... $	6,000	53,115	83,871	87,600	150,645
Workmen ....No.	35	68	95	186	202
Wages paid .... $	10,000	30,406	34,674	106,332	139,548

FELDSPAR

The feldspar or microcline quarries on the line of the Kingston and Pembroke railway last year had an output of 10,983 tons valued at $21,966, which was 4,313 tons less in quantity and $1,920 more in value than the production of 1903. In the latter year the product was given an average value at the mine of $1.31, and in 1904 of $2 per ton. The market is wholly in the United States, mainly among the potteries of New Jersey and Ohio.

For the last five years the figures for the feldspar industry are as follows:

	Tons.	Value.
1900....	4,000	$ 5,000
1901......	5,100	6,375
1902....	8,776	12,875
1903........	15,296	20,046
1904......	10,983	21,966

The number of employees in 1904 was 34, and the amount paid in wages $16,300. The Kingston Feldspar Mining Company and Mr. Charles Jenkins were the producers.

IRON PYRITES

The production of iron pyrites has increased with some rapidity during the last two or three years, the output in 1904 being 13,451 tons worth $43,716, as against 7,469 tons valued at $21,693 in 1903. The chief producer is the American Madoc Mining Company, which operates two deposits in the county of Hastings, one near Bannockburn, and the other in the township of Hungerford. Another mine in the same county is being opened by the British America Mining Company of Toronto. The product is shipped to the United States, where it is used in the manufacture of sulphuric acid.

For the four years beginning with 1901, the production of iron pyrites in Ontario has been as follows:

	Tons.	Value.
1901......	7,000	$17,500
1902....	4,371	14,993
1903......	7,469	21,693
1904......	13,451	43,716

In mining iron pyrites 60 persons were employed in 1904 to whom $22,875 was paid in wages.

MICA

There was a lull in the mica business last year, some 332 tons only of the amber variety having been raised from the mines of this Province, valued at $37,847, as compared with 948 tons worth $102,205 in 1903. The chief producers were the General Electric Company, Sydenham, and Jas. Richardson and Sons and Kent Bros., both of Kingston. The number of persons employed in mining mica last year was 79, and the amount of wages paid them $21,529.

SALT

The brine wells of southwestern Ontario in 1904 produced a total of 55,877 tons of salt, valued at $362,621, as against 58,274 tons worth $388,097 in 1903. The market for Ontario salt does not seem to be increasing, since the output is now less than it was five years ago. The largest producer is the Canadian Salt Company of Windsor, but there are also working plants at Goderich, Wingham, Seaforth, Clinton and Brussels in the county of Huron, Kincardine in the county of Bruce, and Sarnia in the county of Lambton.

The course of the salt business in Ontario for the last five years is shown by the following figures:

Production of Salt 1900 to 1904.

Schedule.	1900.	1901.	1902.	1903.	1904.
Salt produced ....tons	66,588	60,327	62,011	58,274	55,877
Value of product.... $	324,477	323,058	344,620	388,097	362,621
Workmen employed....No	243	189	198	208	193
Wages paid.... $	72,581	67,024	76,154	87,995	84,682

PETROLEUM

The decline in the yield of the petroleum wells of the Province, which has been going on almost uninterruptedly for a number of years, appears to have suffered a check in 1904. The crude product last year was 17,237,220 imperial gallons, as against 16,640,338 imperial gallons in 1903. The value did not rise in proportion, being $904,437, compared with $12,103,016. The increased production is to be credited to the new pools or fields near Leamington, Essex county, which began production in 1903, and in the township of Moore, Lambton county, opened up last year, which yielded 25,241 barrels and 36,971 barrels respectively, the output of these new areas being more than sufficient to offset the shrinkage in the Petrolea district. The production of the various fields, or pools, is estimated as follows, a barrel being the equivalent of 35 imperial gallons:

Field.	Barrels.
Petrolea....	278,299
Oil Springs....	75,530
Bothwell....	47,654
Dutton....	14,217
Leamington....	25,241
Moore....	36,971
Wheatley....	4,490
Raleigh....	3,274
Thamesville....	5,027
Pelee Island....	1,023
Blytheswood....	669
Comber....	97
Total....	492,492

On 8th June 1904 the bounty on Canadian crude petroleum of one and one-half cent per imperial gallon provided by the Dominion Government under chap. 28, 4

Edward VII, became effective—applying as well to oil held in storage tanks or other storage receptacles as to oil produced after that date—and the effect of this encouragement was no doubt to stimulate the production of domestic crude. The quantity of crude petroleum in storage on 8th June and delivered to 31st December, was 9.817,447 gallons, on which a bounty was paid of $147,261.70.

As stated above, the prices of crude oil in Canada as well as in the United States, declined during the year. On June 7th, just before the bounty took effect, and while the import duty of five cents per gallon was in force, the price of Oil Springs, Bothwell and Dutton crude was $2.13 per barrel, and of North Lima crude $1.11 per barrel; on 31st December, the price for Canadian crude was $1.50 per barrel plus bounty 52½ cents per barrel, total $2.02½ per barrel, while the North Lima article sold for $1.01 per barrel.

It is estimated that about 30,555 barrels of domestic crude petroleum were used for fuel and gas-making purposes, leaving say 461,937 barrels available for distillation. This was implemented by the treatment of a large quantity of crude imported from the United States in order to supply the demand for petroleum products and keep the refineries in operation. Since the beginning of 1905 developments, especially in the Leamington field, seem to indicate that a very considerable addition to the supplies of Ontario crude may be looked for, and some are sanguine enough to hope that the output of the Canadian wells may soon prove sufficient to meet the requirements of the home market. The account given in this Report by Mr. E. T. Corkill, Inspector of Mines, who visited the oil and gas fields in the early spring of the present year, will be read with interest.

Owing to the large quantities of American oil now treated in the refineries of the Province along with the domestic article, it is no longer practicable to give the refined products derived from the latter in separate form, hence in the table of statistics the figures are presented of the crude product only.

NATURAL GAS

There was a marked increase in the quantity of natural gas produced in the Province last year as compared with 1903, the value of the output in 1904 being $253,524, and that of the previous year $196,535. The greater portion of the gas is derived from the Welland county field, in which the Provincial Natural Gas and Fuel Company is the principal operator, but in the county of Haldimand a gas field of apparent promise is being exploited with some success. It is proposed to pipe the gas from this district into the city of Hamilton. On the outskirts of Brantford both gas and oil have been found at Bow Park farm and elsewhere, and gas is being supplied for illuminating purposes to the people of that city. In the new oil field at Leamington much gas accompanies the oil, and the inhabitants of that town are once more enjoying the advantages of a gas supply, of which they were deprived when the Essex wells ceased to flow two or three years ago.

A feature of the Provincial Natural Gas and Fuel Company's operations last year was the extension of their supply line to the city of Niagara Falls, Ont., and to the neighboring village of Chippewa. Thirty miles of low pressure lines composed of 6-inch, 4-inch, 3-inch and 2-inch pipes were laid in Niagara Falls and three miles of 3-inch and 2-inch at Chippewa. About 3 miles of 1½-inch and 1¼-inch pipe were put in as service lines from the mains to the meters, and in all some 1,600 new customers were connected during the year. The price at which the gas is sold at these points is 20 cents per thousand cubic feet. Gas is also delivered by that company at Bridgeburg, Fort Erie, Sherkston, Stevensville, Crystal Beach, and other points along the lake shore, as well as to farmers situated along the lines. At these places the price of the gas is 25 cents per thousand cubic feet.

The production of natural gas in the Province for the last five years has been as follows:

Year.	Value.
1900	$392,823
1901	342,183
1902	199,238
1903	196,535
1904	253,524

At the close of 1904 there were 176 producing wells, of which 36 had been put down during the year; there were also 231 miles of delivery pipe, and the number of employees was 98, to whom $53,674 was paid in wages. There were also drilled during the year 13 non-producing wells.

MINOR PRODUCTS

Of actinolite a small quantity—408 tons—was exported during the year, from a deposit in Frontenac county, being valued in the returns at $102. A mill for grinding actinolite into raw material for making fire-proof roofing, paint, etc., has been for many years in existence at Actinolite (formerly Bridgewater) but was last year injured by a flood on the Moira river to such an extent as to cause its stoppage.

The production of arsenic in Ontario suffered an interruption when the Deloro mines were closed down about two years ago, the auriferous mispickel in which furnished a very appreciable proportion of the white arsenic consumed on the continent. A new source of this product has been opened up in the cobalt and nickel arsenides of Coleman township, which have already been mentioned under several headings. The output of last year was wholly from this source, and amounted to 72 tons of arsenic contained in the exported ore, valued at $903. Efforts have been made to bring about a resumption of operations at Deloro, where and in which vicinity there are undoubtedly large bodies of arsenical ore, and some enquiry has also been made into the possibility of establishing works in Coleman to recover this substance from the ores produced there, a nominal price only being realized at present for their arsenical contents.

The graphite obtained last year amounted to 235 tons of the crude article, valued at $4,700. Part of this was refined at the point of production, and part was used in the natural condition. The mines and works at Oliver's Ferry were idle during the year, but an amalgamation of interests has been effected which is likely to lead to renewed activity at that place. The Black Donald mine in Brougham township, formerly operated by the Ontario Graphite Company of Ottawa, has been leased to Mr. Rinaldo McConnell, who took possession 1st May 1904. Being largely interested in the Globe Refining works at Oliver's Ferry, which is now in control of the graphite properties at that place, Mr. McConnell is probably more extensively engaged in the graphite business than any other person in the Province.

From the palaeozoic rocks of the Onondaga formation outcroppings in the valley of the Grand river small quantities of gypsum continue to be mined or quarried from year to year. Formerly this article was more or less in vogue as a fertilizer on certain kinds of soil, but it is now for the most part utilized in the manufacture of wall plaster, kalsomining materials, etc., for which there are factories at Paris and Toronto. There was raised in 1904, 5,412 tons of crude gypsum, worth $10,674. The immense deposits on the banks of the Moose river, described in some detail by Dr. James M. Bell in the Thirteenth Report of the Bureau of Mines will no doubt remain unworked until better means of communication and transport are provided.

In the peat bogs of Ontario is stored up a prodigious quantity of carbon, which may yet be drawn upon in a commercial way and used as fuel. The manufacture of compressed peat by the Dobson process continues at Beaverton, where some 800 tons, worth $2,400, were made in 1904. This industry is also being established at Alfred,

where a plant capable of turning out 50 tons of fuel per day has been erected by the Montreal & Ottawa Peat Co., Limited, with a capital of $75,000 and head office at Ottawa, of which George H. Perley is president and A. W. Fleck secretary-treasurer. The company own a peat-bog comprising 300 acres of first-class quality adjoining the railway. Lying about midway between Ottawa and Montreal, this factory will send fuel into both markets. At the other end of the Province, near Fort Frances, a factory is being put up by the Manitoba Peat Company to work a very large bog of good quality. If a good article of fuel can be produced, of which the promoters of the company have no doubt, it is sure of a free sale in Winnipeg, where anthracite sells for $11 per ton and more, and where in consequence the fuel question is a pressing one. An effort is being made by Messrs, D. H. and E. V. Moore of Peterborough, to introduce the manufacture of peat fuel by the "machine" methods so commonly used in Europe. It is claimed for "machine" peat that being compacted by shrinkage during the process of drying, it will not disintegrate when burning, an objection brought against the briquettes made by compression. Mr. Moore has installed an experimental plant at Victoria Road.

The county of Hastings—whose mineral products excel in number and variety those of any other county in the Province—produced 1,313 tons of talc in 1904, valued at $2,919.

MINING LANDS SOLD AND LEASED

The sales of land for mining purposes in 1904 covered 3,440 acres, and the purchase money received was $8,321.80, as against 6,437 acres sold for $15,123.89 the previous year. The average price per acre realized in 1904 was $2.32, and in 1903, $2.35. Prices of mining lands are regulated by the Mines Act, which provides that if in unsurveyed territory, and more than 12 miles from a railway, the rate shall be $2 per acre, if within 12 miles, but more than 6 miles of a railway, $2.50 per acre, and if nearer than 6 miles, $3 per acre. In surveyed townships, the price is 50 cents per acre more in each class.

Mining leases were issued for 11,002 acres, the first year's rental being $10,762.06, as compared with 33,427 acres and $33,177.61 in 1903.

The amount received as rental under mining leases issued prior to 1904 was $14,558.63, and on account of leases converted into freeholds, $9,920.38.

The receipts from miner's and prospector's licenses was $1,597.15.

Sales

District.	Number of Grants	Acres	Amount $
Rainy River....	13	2,184	4,923.50
Thunder Bay......		132	293.00
Algoma....	1	84	254.00
Elsewhere....	16	1,040	2,851.30
Total....	33	3,440	8,321.80

Leases

District	Number of Leases	Acres	Amount $
Rainy River....	17	2,932	2,932.00
Thunder Bay....	8	770	770.00
Algoma....	30	5,347	5,232.06
Elsewhere....	20	1,953	1,828.00
Total....	75	11,002	10,762.06

MINING COMPANIES

The following list gives particulars of the joint stock companies incorporated or licensed to carry on business in Ontario in some or all of the branches of the mineral industry. The number of companies organized under the laws of the Province was 54, with an aggregate nominal capital of $28,355,000, as against 43 companies in 1903 having a total share issue of $35,534,000. In addition 12 companies of extra-Provincial origin took out licenses enabling them to do business here, their joint combined capital amounting to $21,155,000 as against 12 such companies in 1903, having an aggregate capital of $12,000,000.

Mining Companies Incorporated 1904.

Name of Company.	Date.	Head Office.	Capital.
			$
Bonanza Creek Gold Mining Company, Limited	December 23, 1904	Toronto	1,000,000
Buffalo and Leamington Oil and Gas Company, Limited	December 9, 1904	Windsor	100,000
Canadian Lead Company, Limited	September 27, 1904	Toronto	1,000,000
Cement, Stone and Building Company, Limited	February 8, 1904	Toronto	50,000
Condensed Peat Fuel Company, Limited	December 9, 1904	Peterboro'	40,000
Dominion Cement-Brick Company, Limited	June 30, 1904	Toronto	50,000
Dorion Lead and Zinc Company, Limited	December 5, 1904	Port Arthur	50,000
Fruitland Brick and Supply Company, Limited	July 6, 1904	Hamilton	40,000
Grand Valley Peat Products, Limited	July 26. 1904	Toronto	00,000
International Peat Company, Limited	December 9, 1903	Toronto	[illegible]50,000
Mayo Mining and Development Company, Limited	January 8, 1904	Windsor	[illegible]50,000
Mohawk Natural Gas, Limited	September 7, 1904	Brantford	[illegible]50,000
New York-Lake Erie Oil and Gas Company, Limited	June 22, 1903	Windsor	1,[illegible]00,000
Orion Mining Company, Limited	January 18, 1904	Niagara Falls	1,[illegible]00,000
St. Marys Quarries, Limited	December 30, 1904	St. Marys	[illegible]00,000
Sarnia Bay Lumber, Timber and Salt Company, Limited	January 6, 1904	Sarnia	[illegible]00,000
Silver King Gold and Copper Company, Limited	June 30, 1904	Toronto	2,[illegible]00,000
Sovereign Oil Company, Limited	June 8, 1904	Comber	[illegible]50,000
Sudbury Brick Company, Limited	May 18, 1904	Sudbury	20,000
Victoria Cement and Power Company, Limited	December 20, 1903	Lindsay	00,000
Windsor Gas Company, Limited	October 24, 1904	Windsor	00,000
The Aberdeen Development Company, Limited	January 12, 1904	Tp. of Aberdeen	300,000
The Alpena Oil and Gas Company, Limited	July 27, 1904	Chatham	100,000
The Ballarat Mining Company, Limited	October 5, 1904	Toronto	300,000
The Brick Manufacturing and Supply Company, Limited	December 3, 1904	London	40 000
The British American Development Company. Limited	April 20, 1904	Toronto	1,000,000
The Canadian Cement Brick Company, Limited	January 15, 1904	Toronto	150,000
The Canadian Corundum Wheel Company, Limited	December 23, 1904	Hamilton	40,000
The Canadian Iron Company, Limited	June 15, 1904	Ottawa	2,000,000
The Canadian Michigan Gold Mines, Limited	June 15, 1904	Sault Ste. Marie	1,000,000
The Deep Oil and Gas Company, Limited	January 29, 1904	London	100,000
The Dominion Natural Gas Company, Limited	October 12, 1904	Hamilton	500,000
The East Toronto Brick Company, Limited	October 26, 1904	Toronto	40,000
The Empire Salt Company, Limited	June 22, 1904	Sarnia	50,000
The Goderich Cement Brick Company, Limited	July 29, 1904	Goderich	40,000
The Hamilton and Toronto Sewer Pipe Company, Limited	March 25, 1904	Hamilton	250,000
The Island Granite Company, Limited	March 23, 1904	Toronto	200,000
The Lake Shore Natural Gas Company, Limited	September 16, 1904	Fort Erie	500,000
The Montreal and Boston Consolidated Mining and Smelting Company, Limited	April 27, 1904	Toronto	7,500,000
The Montreal and Ottawa Peat Company, Limited	May 18, 1904	Ottawa	75,000
The Mount McKay Brick and Tile Company, Limited	September 7, 1904	Fort William	40,000
The Niagara Quarry Company, Limited	September 14, 1904	Orillia	40,000
The Nipissing Mining Company, Limited	December 16, 1904	Toronto	250,000
The Northern Iron and Steel Company, Limited	September 13, 1904	Toronto	2,500,000
The Ontario Crude Oil Company, Limited	June 30, 1904	Toronto	300,000
The Owen Sound Natural Gas and Oil Company. Limited	May 27, 1904	Owen Sound	40,000
The Point Pelee Oil and Gas Exploration Company, Limited	August 17, 1904	Leamington	40,000
The Reading Mining Company, Limited	November 30, 1904	Toronto	250,000
The St. Anthony Gold Mining Company, Limited	May 29, 1904	Ignace	1,000,000
The South Essex Oil and Gas Company, Limited	May 11, 1904	Leamington	500,000
The Syndicate Mining Company, Limited	April 15, 1904	Toronto	50,000
The Toronto Pottery Company, Limited	August 19, 1904	Toronto	10,000
The Trout Creek Development and Mining Company, Limited.	August 17, 1904	Trout Creek	100,000
The Western Salt Company, Limited	December 9, 1904	Mooretown	100,000
			$28,355,000

Licensed Mining Companies, 1904.

Name of Company.	Head Office in Canada.	Date.	Capital for use in Ontario.
			$
Ashland Emery Corundum Company	Ottawa	June 17, 1904	75,000
Big Master Mining Company	Gold Rock	October 5, 1904	300,000
Craig Mining Company	Bannockburn	February 13, 1904	50,000
Madoc Mining Company	Madoc	December 14, 1904	40,000
Minnehaha Mining and Smelting Company	Wabigoon	August 24, 1904	40,000
The Camp Bay Gold Mining Company of Ontario, Limited	Detroit, Mich. Rat Portage, Ont	October 26, 1904	100,000
The Detroit and Parry Sound Mining Company, Limited	Parry Sound	May 11, 1904	50,000
The Eldorado Mining Company	Rat Portage	June 30, 1904	50,000
The Leamington Oil Company, Limited	Leamington	December 30, 1903	100,000
The Pacific Coal and Oil Company, Limited	Toronto	May 11, 1904	17,500,000
Traverse City Gold Reef Company	Traverse City, Mich	March 16, 1904	2,800,000
Young's Lake Mining Company	Webbwood	April 20, 1904	50,000
			$21,155,000

MINING ACCIDENTS

The number of mining accidents in 1904 was less than in 1903, but the proportion of fatalities was greater, no less than seven men being killed out of a total of eleven casualties. The year was marked by one of the severest and most regrettable accidents in the history of mining in this Province, by which at the Shakespeare gold mine on the morning of August 2nd, six men went down to their death into the poisonous fumes of dynamite lingering at the bottom of the shaft after the setting off of a blast. A fuller account of this disaster is given below.

Canadian Copper Company.

At the Canadian Copper Company's works and mines at Copper Cliff four accidents happened during the year, resulting in the death of one man.

On March 30th Gaudense Dominick, an Italian, had his leg broken below the knee while helping to carry an "I" beam at the Ontario smelting works. In letting the beam down it rebounded, striking him on the leg and breaking it. As a result he was laid up in the hospital until some time in May.

On April 28th at 5.15 p. m., Isaac Isaacson, aged 22, and Mick Pentila, aged 18, two Finlanders employed at the Creighton mine, fell from a rock trestle and received serious injuries. Mick Pentila's injury consisted of a simple fracture of the left thigh, and a not very serious contusion of the knee of the same leg. In the case of Isaacson the injuries were more severe and resulted in his death the following day. He sustained a comminuted fracture of the skull in the left temple region, as well as a compound fracture of the left collar bone. An operation was performed in the hope of relieving the man's condition by trephining, removing and elevating the fractured and depressed bone. He was removed to the hospital at Copper Cliff, where he died about 2.30 p.m., April 29th. Mr. Thomas Oliver, coroner, held an inquest before a jury on April 30th, who returned a verdict of accidental death. The inquest brought out the fact that the two injured men were working on a rock trestle along with two others. The trestle was 25 feet high, with a railing three feet high on both sides. The two men were leaning against this railing, when it suddenly gave way, allowing them to fall to the rocks below. In the case of Pentila recovery took about ten weeks.

On the 22nd June, Joseph Yamary, while working in the Copper Cliff rock dump, slipped and fell, sustaining a fracture of the bones of the left forearm. He was taken to the hospital and laid up for a few weeks.

On 25th November, Andrew Dingler, a laborer in the rock house at Creighton mine, had his leg broken by being carried around a pulley, resulting from an attempt to throw a belt off the pulley with his foot. He sustained three fractures of the right leg below the knee. He was taken to the hospital at Copper Cliff.

Shakespeare Gold Mine

On 2nd August 1904 between 7 and 7.30 a.m., six men lost their lives at this mine by asphyxiation or poisoning, or both, from inhaling the "smoke" or gases, in the underground workings, resulting from a previous blast of dynamite. The deceased were N. Macmillan, superintendent, Peter Reed, engineer and blacksmith, Joseph Disley, Peter Grant, John Waters and Eli Latour, miners. An investigation into the circumstances surrounding this fatality was made by Mr. W. E. H. Carter, Inspector of Mines, whose report is substantially as follows:

The total force at the mine was seven, and only the seventh man, who worked on the surface was left alive. The former superintendent, Jas. Cronan, was however present at the time of the accident, and also W. E. Seelye, vice-president of the company, the Shakespeare Gold Mining Company, Limited. A number of outsiders from the adjacent Foley mine and the town, etc., were immediately summoned and quickly appeared on the scene. Mr. Macmillan had been in charge of the property from 22nd July, a period of 10 days. The mine workings measured as follows, at date of August 2nd 1904: Shaft, 95 feet deep, vertical, and 7 feet by 7 feet in size inside and to bottom of timbers (down to the tunnel or 53-foot level) and decreasing below this to about 6 feet by 6 feet in the rock at bottom. The tunnel, driven N. W. 75 feet, intersects the shaft at its face at 53 feet depth; and from the same level drifts run S. W. 43 feet and N. E. 37 feet, with a crosscut S. W. 17 feet from the face of the latter. The second level is at a depth of 90 feet, and consists merely of a crosscut running S. W. 33 feet, directly under the tunnel. The 4 or 5-foot sump at bottom of shaft is usually full of water, and was so on 2nd August. Entrance to the lower workings is by the tunnel and down hanging ladders in the shaft. The two shaft compartments have not been partitioned off. Hoisting is done by bucket and steam hoist engine.

The surface plant at the mine consists simply of a power house containing a 40- or 50-horse power boiler, the hoist engine and a 3-drill Ingersoll air compressor, all apparently in fair if not good working order.

There had been no night shift for a while previous to the 2nd August, the two crews of miners of two men each working on day shift only, one driving the second level S. W. crosscut, in the face of which the blasting was done which was the indirect cause of the accident; and the other the first level N. E. drift.

Following the usual custom, the blast was set off at the end of the shift, at about 5.30 p. m. There were five holes, and of these three were set off first by themselves at the above hour. The air was then blown in from the compressor until 6.30, or after supper, when one of the crew went down into the mine and set off the remaining two holes. The air hose was hung up in the shaft above the lower crosscut and remained there until next morning, no attempt being made to blow out the gas from this second round of holes. Now, in such cases as this, namely when blasting had been done subsequent to the last exit of the miners, the orders from the superintendent to the engineer were that the latter should blow out the smoke with air from the compressor for at least about 10 minutes, (no stated period specified and the order being to that extent indefinite) before the men went down to work in the morning again. If there was a night shift as well as day, with blasting at the end of each, the compressor was kept running for the hour or more between the two shifts blowing out the smoke and gases, the next shift finding the air good by the time they were ready to descend. This precaution had latterly, with the extension of the lower workings, been found necessary, because the natural draught, at all times very poor, could not be relied

upon to clarify the air. A strong draught prevails most of the time through the tunnel and up the upper half of the shaft; but this did not stir up any appreciable circulation of the air in the shaft and crosscut below the tunnel level. These facts appear to have been well known to the deceased men, particularly to the four miners who went down the workings first. It has also been shown that this portion of the shaft was blue with smoke, which should have been sufficient to deter men from entering before fresh air was supplied them.

On the morning of the accident the engineer, Peter Reed, had gone to the power house before breakfast and put a fire in the boiler so that steam was up to about 40 pounds at 7 a. m. But instead of returning there again before 7 a. m. and starting the compressor so that the men might have fresh air when they went down, he went over in company with the miners. Just at 7 a. m., as the whistle blew, the four miners went in the tunnel and descended the shaft. Only two should have gone down, since the other two were working in the drift on the tunnel level. It is not known why the whole four of them descended. However, on the way down they took the air hose from where it lay on the timbers just above this bottom crosscut and had time to carry it in to the face of this crosscut; but there one man dropped across it, and two dropped at the mouth of the crosscut and the fourth fell into the shaft sump, all overcome by the gas. Total paralysis or unconsciousness was not immediate; their shouting, or at least one shout, was heard from the power house at the mouth of the tunnel just after their descent, and on hearing it Reed and the other surface man rushed into the tunnel and heard the men groaning also. All signs of life disappeared, as nearly as can be ascertained, within one or two minutes of their descent, due no doubt of paralysis, followed by unconsciousness. Death itself would not necessarily follow for some minutes after, and had the men been raised to the surface within a short time they might even then have been rescusitated.

Reed, instead of rushing back again and starting the air compressor to give the men air, went down the ladders himself and fell off into the sump, overcome. It was probably then about 7.05 a.m. The superintendent, Mr. N. Macmillan, with Mr. Cronan, then arrived on the scene from the boarding house and in a few minutes—variously stated at from 10 to 15 minutes—the air compressor was put in operation and air blown below. The bucket in the shaft was at the same time raised and lowered continuously to help start an air current. Macmillan (about 7.20 a. m.) went in the tunnel again, and then he also went down the shaft, and, like the engineer, dropped off before reaching the bottom.

Cronan then took charge of things, and let down a second line of air hose; but not until about 10 a. m. did anyone venture to enter the workings again. The deceased men were then raised to the surface. Their appearance differed but little from when alive, according to the evidence of the bystanders. This leads to the belief that, besides carbonic acid gas and nitrogen, there was a relatively large percentage in the gases of carbon monoxide, which is a poison, alone producing unconsciousness immediately.

The remaining dynamite was not in the best of condition apparently (1) because since its arrival in December 1903 the boxes had not been once turned over, and this had caused the nitro-glycerine to partially settle to the lower side of the cartridges; and (2) because on account of leaks in the roof of the magazine, the upper layer or two of cartridges in each box had absorbed considerable water. The explosion of such dynamite in all probability would be attended with the generation of more smoke and gas than that from good, fresh dynamite, so that is is quite possible, if not likely, that the charge on the night previous to the accident produced an extra quantity of the injurious gases. The dynamite was made by the Ontario Powder Company, and, according to the evidence, has given satisfaction, the only misfires reported, according to James Cronan, being due to unexploded detonating caps.

Table of Mining Accidents 1904

No.	Date.	Mine or works.	Name of injured person.	Result of injury. Slight.	Serious.	Fatal.	Above ground.	Below ground.	Nature of injury.	Cause of accident.
1	Mar. 30 ...	Canadian Copper Co.	Gaudense Dominick	....	1	....	1	....	Leg fractured	Struck on leg by beam.
2	Apr. 28 ...	Canadian Copper Co., at Creighton mine.	Isaac Isaacson	....	....	1	1	....	Skull fractured	Fall from rock trestle.
			Mick Pentila	....	1	....	1	....	Fracture of left thigh	
3	June 22 ...	Canadian Copper Co.	Joseph Yamary	....	1	....	1	....	Arm broken	Fell on rock dump.
4	Aug. 2 ...	Shakespeare Gold Mining Co.	N. Macmillan	....	....	1	....	1	Asphyxiation	Inhaling poisonous gases.
			Peter Reed	....	....	1	....	1		
			Joseph Disley	....	....	1	....	1		
			Peter Grant	....	....	1	....	1		
			John Waters	....	....	1	....	1		
			Eli Latour	....	....	1	....	1		
5	Nov. 25 ...	Canadian Copper Co., at Creighton mine.	Andrew Dingler	....	1	...	1	....	Leg Broken	Carried around a pulley by belt.
		Total		....	4	7	5	6		

Total casualties, 11.

The bodies were removed and buried by the relatives of the deceased. No post mortem examination was made upon any one of them. This should have been done, however, for the determination if possible of the particular gas, if there was one in particular, and if not, then of all the gases, which caused death.

That death was due to inspiring noxious or poisonous gases cannot be doubted; nor that these gases were generated by the explosion of the charge of dynamite on the evening previous; and it is possible if not probable that the condition of the dynamite caused the formation of an undue percentage of these gases. The dynamite, however, cannot be blamed, since in its explosion these gases are always generated in dangerous quantities. The accident was due to the failure of the engineer, Peter Reed, to blow out the smoke and gases from the mine before the men went down, and to the carelessness of the men themselves in entering the workings before fresh air was blown in. Superintendent Macmillan, and also engineer Reed, sacrificed their lives in an effort to save their fellows, but unfortunately without any forethought, for otherwise they would have recognized the certainty of their own death in the course they took, and would have made more effectual efforts from the surface, where they were so badly needed.

THE DIAMOND DRILLS

The last operations of the "C" diamond drill in 1903 were in Dufferin county. In June of 1904 the drill was placed at the disposal of the Black Bay Mining Company to be used on their property in exploring for copper. This property is location McA 217 on the east side of Black bay, lake Superior, and is 46 miles from Port Arthur by boat. Considerable development work had already been done, a shaft having been sunk to a depth of over 100 feet. Some ore had been found up to this depth, when a sandstone formation was encountered. This property is described in the Thirteenth Report of the Bureau of Mines. It was thought that the ore body would be found again at a greater depth, so a vertical hole was drilled to a depth of 1,000 feet. The rocks traversed by the drill were chiefly amygdaloidal trap, sandstone, quartzite and conglomerate.

Only one hole was bored at a total cost of $1,033.82, or $1.03 per foot, and the net cost to the operators amounted to $672.00, or $0.67 per foot, while the gross cost of diamonds per foot was $0.28.

When drilling operations ceased at Black bay, the drill was moved to Port Arthur and thence to Loon lake, to be used by Wiley & Company, on lot 8 in the seventh concession of McTavish, District of Thunder Bay. This district has been described in the Twelfth Report of the Bureau of Mines, page 310.

The property has been prospected quite thoroughly by test pits, and three shafts had also been sunk to depths of 20, 25 and 30 feet respectively. The higher formation shows iron exposed without any taconite covering, but south of this the covering seems to grow thicker. Ore of fine quality is found where the taconite covering is lacking.

The special Committee on the Nomenclature and Correlation of the Geological Formations of the United States and Canada visited this area in 1904, and described the succession as follows: "The top series is the Keweenawan, here consisting of sandstone above and conglomerate below, with interbanded basic igneous flows. Below the Keweenawan is the Animikie. The Animikie here has in general rather flat dips, although locally they become somewhat steeper. At the base of this formation is a conglomerate, bearing fragments of the next underlying series—a graywacké slate."

Summary of Operations with Diamond Drills

Firm or company.	Location of drilling.	Kind of Mineral.	Rock drilled through.	Total depth drilled.	Total cost.	Total cost per foot.	Net cost.	Net cost per foot.	Gross cost of diamonds per foot.	Drill.
				ft.	$	$	$	$	$	
Black Bay Mining Co..	Location McA. 217, Black Bay	Copper..	Amygdaloidal trap, sandstone, quartzite and conglomerate	1,000	1,033 82	1 03	672 00	67	28	"C"
Wiley & Co.	Lot 8, concessions 7 and 9, township of McTavish, district of Thunder Bay	Iron	Taconyte, slate conglomerate, and greywacke	199.5	708 10	3 55	460 25	2 31	75	"C"
			Total	1,199.5	1,741.92	....	1132.25	....	....	
			Average	....	....	1.45?	....	.94	.94	

Four diamond drill holes were sunk by Wiley & Company on their property having depths of 48, 60, 45½ and 46 feet respectively, or a total of 199½ feet.

The ore occurred underlying the taconite, and in some cases the ore and taconite occurred very regularly in layers. Underlying this formation conglomerate and graywacké were encountered.

The total cost of drilling 199.5 feet was $708.10, or $3.55 per foot, being a net cost to the operator of $460.25, or $2.31 per foot, and the gross cost of diamonds amounted to $0.75 per foot.

The "S" diamond drill was in operation in Parry Sound District near Burk's Falls until February of 1904. An account of this is given in last year's Report of the Bureau of Mines.

In September the drill was sent to the northeast arm of lake Temagami to bore for iron for Mr. T. B. Caldwell, *et al.* The iron in this district is a magnetite, generally interbanded or closely associated with jasper. A description of the iron ore of the district surrounding lake Temagami is found in the Tenth Report of the Bureau of Mines.

Iron ore was reported to have been discovered in the vicinity of this lake in the autumn of 1899. Little however was done for some time, owing to the lands lying within the Temagami Forest Reserve. In 1902 regulations were passed allowing prospecting for minerals in the Reserve. Also, the building of the Temiskaming and Northern Ontario railway made the deposits easy of access.

Great difficulty was encountered in drilling. At a depth of 194 feet a cavity was encountered, from which there was a very heavy flow of water. The cavity also contained loose and broken boulders of chert. The hole was reamed to a diameter of two inches, and casing inserted, but it was found impossible to drive owing to the number of boulders. The hole was, therefore, abandoned. The rocks passed through were greenstone, diorite and chert.

The total cost of drilling, exclusive of the operations at Lake Temagami, was $1,741.92, or $1.45 per foot, the net cost to the operators being $1,132.25, or $0.94 per foot, while the gross cost of diamonds per foot was $0.94.

Owing to the late season, drilling was abandoned for the time.

PROVINCIAL ASSAY OFFICE

Mr. A. G. Burrows, in charge of the Provincial Assay Office, Belleville, furnishes the following report of its operations in 1904:

The Provincial Assay Office was established in 1898, by the Ontario Government, with a view of aiding the mineral development of the Province. Since this time it has been of much convenience to the public, affording facilities for obtaining reliable and independent examination of materials at reasonable rates.

The samples for examination are chiefly from the newer portions of the Province, where the search for mineral wealth is more active than in the older parts. During the past year that portion of Ontario along the line of the Temiskaming and Northern Ontario railway has been partially explored, and various ores of great value have been found. Besides the silver-nickel-cobalt deposits, copper and iron ores have been located, and samples of these have been examined at the office. Increased activity in iron exploration in Rainy River district, has proved the presence of valuable iron deposits. Samples analyzed at the office were very promising. Some of these are high in sulphur, but many are of Bessemer grade. As in former years the bulk of gold ore samples came from western Ontario, with occasional samples from other parts. The copper ores were chiefly from the region between Sault Ste. Marie and Parry Sound.

Other materials examined were zinc, lead, molybdenum and nickel ores, limestones and clays, corundum, sulphur and arsenic ores, besides some artifical products.

During the year 792 samples were analyzed in whole or part, giving the percentages of metal, etc.; while 173 specimens were reported on as to commercial value, being identified either by hand examination or qualitative methods. The analytical work is checked off in duplicate to minimize the chance of error in issuing certificates.

Work for Bureau of Mines

The following services have been performed for the Bureau during the year:

(a) Issuing reports on samples collected by government geologists during their summer's explorations. The material submitted included:

(1) Iron ores from the iron ranges of Michipicoten district.

(2) Cobalt-silver-nickel ores from the vicinity of Cobalt. Besides making many analyses of the various ores of the district, special attention was given to working out the chemical composition of many of the accessory minerals, which have a scientific interest. These are referred to in Prof. Miller's reports on this region.

(3) Peat samples from northern Algoma and Nipissing. On analysis, these proved to be of fine quality and suitable for the manufacture of peat fuel.

(b) Issuing check reports on pulped samples of iron ore raised and smelted in Ontario, on which it was proposed to claim the bounty provided by the Iron Mining Fund.

(c) Additional analyses of limestones, for report on the limestone industry of the Province. Some of the samples were found to be of great purity, so that material is at hand for any of the purposes for which quality is required, such as sugar refining, paper manufacture, cement, etc.

Work for Private Parties

The following services have been performed for the public, during the year:

(a) Issuing reports, consisting of assays, analysis, identifications and other commercial tests. While a fee on a reduced scale is charged for the work, it is required that it be paid before certificates are issued.

(b) Supplying information where possible to owners of mineral lands and others, who desire to be placed in touch with purchasers, and also advising as to value, uses, etc., of their materials.

(c) Making check determinations and control assays, in case of disputes as to correct values.

(d) Sending samples of ores and minerals to parties desiring to use them for comparison in prospecting.

The varied nature of the analytical work required of the office during the year may be seen from the following list of determinations.

Assays.	For Bureau.	For Public.	Total.
Gold (amalgamation)	2	4	6
Gold (fire assay)....	43	428	471
Silver....	50	143	193
Platinum....	2	14	16
Cobalt....	20	7	27
Nickel..	20	32	52
Copper....	12	62	74
Manganese....	1	7	8
Bismuth....	2	0	2
Molybdenum....	1	4	5
Zinc....	4	8	12
Lead....	4	10	14
Tin....	1	1	2
Arsenic....	17	2	19
Antimony..	4	0	4
Total	183	722	905

Analyses.

Metallic iron	76	28	104
Alumina	91	38	129
Silica	95	23	118
Lime	93	17	110
Magnesia	93	15	108
Ferric oxide	79	15	94
Ferrous oxide	6	2	8
Sulphur	136	34	170
Moisture	78	8	86
Alkalies	62	12	74
Organic	37	0	37
Phosphorus	40	10	50
Titanium	13	10	23
Miscellaneous	197	32	229
Total	1,096	244	1,340

Total Assays	905
" Analyses	1,340
" Identifications	172
Total Determinations	2,417

Location

The office is located in the city of Belleville, on Victoria avenue, and is housed in a two-storey brick building. The lower floor is utilized as an office, with grinding room in the rear, while the upper floor is devoted to analytical purposes. The laboratory is equipped for making all mineral analyses.

Methods

The following methods are used:

Gold and silver (1) by fire assay, using gasoline for fuel. Owing to the great variety of ores treated, it is found more satisfactory to roast all ores containing sulphur and arsenic, rather than attempt to eliminate these elements during fusion. Two furnaces are used, a large Hoskins for making a number of assays at a time, and a smaller one for limited work. An assay balance, sensitive to one one-hundredth of a milligram is used for weighing the beads and residues. (2) By amalgamation, to test the free milling character of the ore.

Platinum: By fire assay.

Copper: By cyanide titration, and electrolytic methods.

Nickel and cobalt: By electrolytic method. For this purpose a set of potash cells (Edison Primary) is used. The metals are plated together, and afterwards separated by dissolving, and precipitating cobalt as potassic cobaltic nitrite.

Lead: By ammonium molybdate titration method.

Zinc: By titration with potassium ferrocyanide.

Other determinations are made by standard methods.

All samples are pulped to 100-mesh, and those requiring finer reduction are ground in an agate mortar to an impalpable powder. Wet ores are dried at 100 C. and analysis reported at that temperature. In other cases the analysis is reported at ordinary temperature.

Notes

Samples brought personally to the office are examined free of charge, except where quantitative work is desired. Circulars of rates, sample bags and mailing envelopes are supplied to those desiring to send in samples.

One laboratory assistant was employed during the year. Mr. G. H. Hambly acted as assistant till first of October, when he left to accept a position in the chemical laboratory at Helen mine, Michipicoten.

Fees amounting to $830.30 were collected and remitted to the Bureau of Mines.

MINING AGENCIES

Sudbury

Mr. T. J. Ryan, Crown Lands and Mining Agent at Sudbury, makes the following report:

I beg to submit a short account of the workings of the Mining Lands agency at Sudbury during the year 1904.

The Mining agency, which is carried on in conjunction with the Crown Lands agency, with 29 townships open to prospectors, was opened in 1900. In 1901, 1902 and 1903, there was great activity in prospecting and taking up mining lands. During some of these years this agency sent in applications for over 15,000 acres, and paid in over $2,100 in cash in the year on account of mining lands.

The year 1904 was less active. This was partly due to the short and very rainy season, making it almost impossible to use the tote roads and trails, especially in low lands. Another reason was the fact that many of the prospectors were attracted to the new Temiskaming country, along the Government line of railway, by the discovery of rich deposits of cobalt, nickel, arsenic and silver ores. All applications would go in from the agency in that district, or direct to the Department at Toronto.

This Mining agency is extensively used from all parts of the district by prospectors and others, both by letter and personally by use of the Land Roll open to every person free of charge. Mining maps, reports, Mines Acts, blank forms of affidavits and applications, etc., are all kept on hand and furnished free or mailed to prospectors who cannot get in. The map issued by the Department of the "Sudbury Nickel District" is always in demand.

However, operations with the mining companies in the district have been active, especially with The Huronian Company, where the work in developing water power on the Spanish river has been of a gigantic nature. The North Star mine also changed hands to the Mond Nickel Company, and is being actively developed, with entirely gratifying results.

The year 1905 will see a great revolution in mining here, when the water power companies commence to generate electricity.

The summer mining schools or classes conducted here each year give satisfaction and are a great benefit to prospectors and others. The Provincial Assay Office has been of splendid service to prospectors and those who want to obtain reliable reports on their finds.

Rat Portage

Mr. N. Seegmiller, Mining Agent at Rat Portage, reports as follows:

I beg leave to submit the following report covering the work of this office with regard to mining lands for the year 1904.

A great many inquiries were received for information about the mining lands and minerals of this district, all of which received careful attention. Maps and reports of the Bureau of Mines were furnished upon request.

Very few new locations were taken up during the year and but few properties were worked. The Eagle Lake district was fairly active, most of the exploring and development work being done there. In the Lake of the Woods district the Sultana, Black Eagle, Golden Horn and Olympia mines did considerable work and were visited by American and foreign capitalists.

The receipts of this office were derived chiefly from rentals and the sale of leased lands.

Enquiries were received about the country lying north of the Canadian Pacific Railway along the proposed route of the new transcontinental line, but as no authentic maps of this territory are available and but little known of its mineral resources, not

much information could be given. This part of the Province no doubt will receive a great deal of attention during the coming summer.

Michipicoten Mining Division

Mr. D. G. Boyd reports as follows:

The year 1904 was the quietest, both as regards the staking of claims and development of prospects, in the history of the district. Owing to the continued dulness, the local office was closed at the end of July, and the business was thenceforward carried on from Toronto.

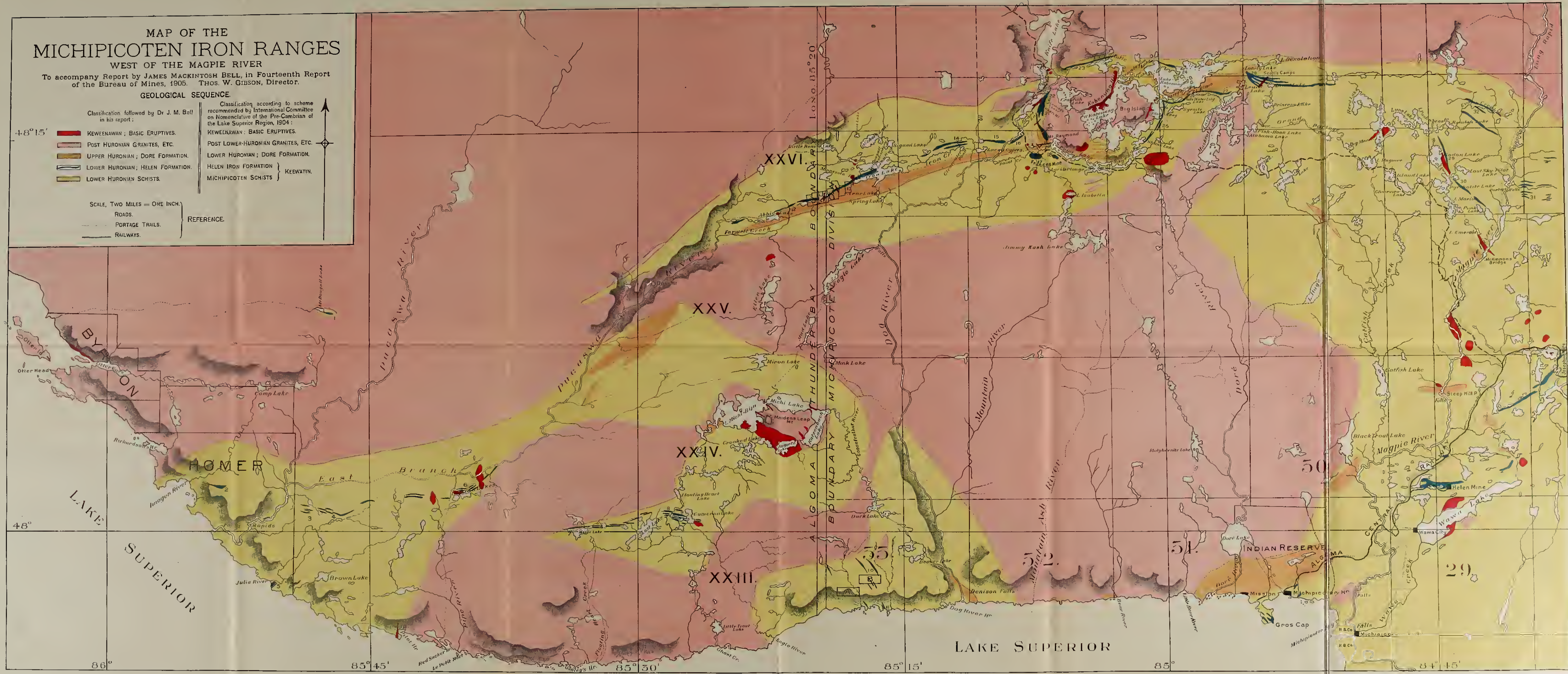
The total number of licenses issued during the year was 89, and the number of claims registered 70, while the total amount of fees received was $1,504.

Little was done in the way of actual mining except at the Helen iron mine, which resumed operations in July, and continued steadily at work for the remainder of the year.

Appended is a list of licensees, giving place of residence, number of license and number of claims (if any) registered during the year. Where not otherwise indicated, the licensees are residents of Ontario.

License.	Residence.	No. of License	No. of Claims.
Abbott, S. G.	S. S. Marie, Mich.	1419	
Armstrong, T. H.	Michipicoten River	1458	1581
Barr, W. C.	S. S. Marie	1491	1608
Barton, S.	Michipicoten River	1478	1582
Beebe, W. D.	Titusville, Pa	1464	1577
Begg, T. J.	White River	1465	
Blackinton, A. B.	S. S. Marie	1431	
Brown, E.	"	1448	1572
Brown, Marie	"	1462	1591
Brundage, J. M.	"	1441	1562
Carleton, C. C.	S. S. Marie, Mich.	1454	1620
Carr, J.	Michipicoten River	1480	
Chappelle, B.	Onaway, Mich.	1417	
Chisholm, D. H.	S. S. Marie	1488	1599 1603
Connors, J.	S. S. Marie, Mich.	1476	1585
Davis, L. H.	S. S. Marie	1493	1617, 1618, 1619
Dawson, P. U. B.	"	1494	1601
Dickson, J. L.	Michipicoten River	1471	1565, 1566
Donoghue, T.	S. S. Marie	1487	1598, 1604
Doore, W. E.	S. S. Marie, Mich.	1443	
Doyle, J. P.	Wawa	1418	1558
Dycie, J. G.	Michipicoten River	1423	1557
Dycie, M.	" "	1416	1556, 1559, 1578
Eldridge, R. C.	S. S. Marie, Mich.	1481	
Everett, W. C.	S. S. Marie	1442	
Godon, A.	Missanabie	1452	
Godon, J.	"	1453	
Godon, P.	"	1434	
Goetz, A.	S. S. Marie, Mich.	1438	1583
Goetz, G.	" "	1445	1586
Goetz, J.	" "	1440	1584
Goetz, M.	" "	1446	
Goetz, R.	" "	1439	1587
Gravel, A.	Wawa	1470	1590
Grover, M. B.	S. S. Marie	1469	
Hecox, C. W.	S. S. Marie, Mich.	1455	1621
Hodgson, J. V.	S. S. Marie	1482	1595, 1605
Holbrook, H. B.	Michipicoten River	1449	1570
Hunt, J.	" "	1503	1574
Irving, J. E.	S. S. Marie	1492	1600, 1606
Johnson, J. B.	Michipicoten River,	1473	
Jones, C. H.	S. S. Marie	1485	1609
Kennedy, T. J.	S. S. Marie	1484	1597, 1602
Kitchi Gammi Gold Mng. Co., Limited	"	1415	

License.	Residence.	No. of License.	No. of Claims.
Legge, C. H.	Gananoque	1506	
Legge, J.	"	1505	
Lemieux, M. C	Wawa	1459	1575
Letellier, J. T.	"	1429	
Martin, F. J. S	S. S. Marie	1497	1593
May, E	Michipicoten River	1437	
Michael, G. F.	S. S. Marie	1436	
Miller, E. H.	St. Thomas	1428	
Miller, G. L	"	1427	
Miller, J. M	"	1426	
Miller, R. J	"	1425	
Murray, T. H	S. S. Marie	1496	1594
McDonald, M. F	S. S. Marie, Mich	1420	
McDougall, L.	White River	1502	
McDougall, W. H	"	1451	
McPhail, D. P	S. S. Marie	1498	
Newton, E. L	S. S. Marie, Mich	1475	1589
Newton, H. L.	" "	1474	1588
Orchard, F	S S. Marie	1433	1561
Parks, G. F	Marysville, Cal	1467	
Plummer, H. L	S. S. Marie	1468	
Pononish, A	White River	1450	
Pratt, W	Michipicoten River	1472	1580
Premier Gold Mining Co	St. Thomas	1507	
Reed, G	Michipicoten River	1500	1569
Reed, S	" "	1501	1568
Riberg, J	S. S. Marie, Mich	1463	1576
Sayles, C. N	S. S. Marie, Mich	1430	1622
Shafer, F.	" "	1435	
Stolle, H. H.	Tripoli, Wis	1479	1579
Touchette, J	Missanabie	1421	
Towers, H. H	S. S. Marie	1495	1592
Towers, T. A. P.	"	1447	1571
Travis, R. L.	Michipicoten River	1444	1567
Trotter, A	S. S. Marie	1432	1563
Trotter, T. W	"	1424	1564
Walker, G. H	Wawa	1466	
Warren, S.	S. S. Marie	1486	1610, 1614
Webster, W	S. S. Marie, Mich	1456	1623
Wilde J. A	S. S. Marie	1483	1596, 1607
Willmott, A. B	"	1490	1615, 1616
Wright, K.	"	1499	
Wynn, J. S.	"	1489	1611, 1612, 1613



SOURCES OF INFORMATION.

Surveys by J. M. BELL.
Topographical map furnished by The Algoma Commercial Company, Limited.
Chart of Lake Superior.
Geological map of Michipicoten Iron Range by A. P. Coleman and A. B. Willmott (Eleventh Report Bureau of Mines, 1902), also geological reports by these gentlemen

SUMMER MINING CLASSES

BY W. L. GOODWIN

Itinerary

Preparations were begun on April 29th. Although large quantities of minerals have been collected for the purpose, it was still found necessary to purchase a few to fill out gaps in the collections. Instead of carrying the whole outfit of minerals from place to place, a box was made up for each place, and sent by express from Kingston about a week before the date of beginning the class. In this way the luggage was reduced, and much labor was saved in packing and unpacking. It also made the luggage more manageable in cases where portaging was necessary.

The writer left Kingston May 2nd, accompanied by Herbert Van Winckel, and camped that night at the pyrite mine of the Madoc Mining Company, near Bannockburn. The journey was made via Grand Trunk railway to Trenton, and thence by Central Ontario railway to Bannockburn, from which place a drive of two miles brought us to the mine. The class was opened on Tuesday, May 3rd, in the "dry" fitted up by the company for the purpose. It was closed on Saturday, May 7th. On Monday, May 9th, I left for Parham Station via Kingston, where a few hours were spent in completing preparations for the summer's work. I left Kingston by the Kingston and Pembroke railway on Tuesday, May 10th, and arrived at Long Lake zinc mine (Jas. Richardson & Sons) on the same evening. The class was opened at 6 p. m. on Wednesday, May 11th, in the dining room. On Friday, May 13th, I was joined by Mr. J. Watson Bain, of the School of Practical Science, Toronto, who took part in the work of the classes from that time forward. The class at Long Lake was closed on Tuesday, May 17th. On Wednesday, May 18th, we proceeded to Eganville via Renfrew and Canada Atlantic railway. Arriving there on Thursday, we were met by Mr. D. J. McCuan, manager of the Radnor iron mine. He drove us out to the mine about eight miles southeast of Eganville. The class was opened at 6.30 on the same day, and closed on Wednesday, May 25th. Returning to Eganville we continued the journey by the C. A. R. to Barry's Bay, thence by steamer *Hudson* to Combermere, whence the steamer of the Canada Corundum Company carried us to Craigmont. The class was opened there at 6.45 p. m. on Friday, May 27th, and closed on Thursday, June 2nd. On Friday, June 3rd, the company's boat *Ruby* carried us to Barry's Bay. Here we took train for Mattawa via Renfrew, and arrived on Saturday, June 4th. There the Ottawa branch of the C. P. R. was followed up to Temiskaming, whence the steamer Meteor took us to Haileybury. The class was opened there on Monday, June 6th. On Tuesday Mr. Bain opened a class at New Liskeard, four miles north, where he carried on the work for four days. The class at Haileybury was closed on Saturday, June 11th. Monday, June 13th, was spent in collecting niccolite and smaltite five miles south of Haileybury. We left by steamer Meteor on Tuesday, June 14th, just in time to escape the smallpox quarantine. We arrived at Sudbury on Wednesday, June 15th, and drove on the same day to the Creighton mine, twelve miles, stopping at Copper Cliff to pick up the box of mineral specimens which had been expressed on from Kingston. At Copper Cliff we met the president, Mr. A. P. Turner, who made arrangements for the class at the Creighton, and then showed us over the new works now approaching completion. Opened the class at 7 p. m. on the same evening, and closed it on Tuesday, June 21st. The next morning, we drove to Copper Cliff station, and took train for Massey station, where we engaged Mr. Campbell, liveryman, to

drive us to the mine, five miles. Captain Sommers was in charge in the absence of Messrs. Errington and Barclay. The class was opened on Thursday, June 23rd, and closed on Tuesday, June 28th. On Wednesday we proceeded to Sault Ste. Marie, but found that the Algoma Central train did not leave for Superior mine until Friday morning. We were therefore obliged to spend Thursday at the Sault. On Friday, July 1st, the journey was resumed. At Superior Station, 40 miles from the Sault, we found the mine wagon waiting for us as arranged by the manager, Mr. Frank Perry. The mine is four miles from the station, and the road being rough, the journey was very slow. Capt. Derry made us welcome, and the class was begun the same evening. The work was completed on Friday morning, July 8th, and the mine wagon took the luggage to the station in the afternoon. Walking out, we caught the train and arrived at Sault Ste. Marie in the evening. We proceeded by C. P. R. steamer Manitoba to Port Arthur, arriving there on Monday, July 11th. Mr. T. R. Jones, manager of A L 282, now called the Sunbeam, arranged for our transportation, and we took the Canadian Northern express to Atikokan station, 142 miles from Port Arthur. Having slept there, we took the local returning east on the morning of July 12th, and reached the Hospital, only to find that the packers had left. However, under the energetic guidance of Pete Dugal, we hurried after them, and found them on the long portage between lakes Sabawe and Asinawe. They (Marcotte and Lepine) returned with us to the Hospital, and took charge of the luggage. The distance to the mine is thirteen miles by canoe, with five portages, most of them very short. The mine was reached too late to start the class that evening. On Wednesday, July 13th, work was begun, and continued until Wednesday, July 20th. On Wednesday, July 20th, we left the Sunbeam by canoe and reached Hematite Hospital at noon. Took the local train to Atikokan, slept there, and caught the express for Port Arthur next morning. We left Port Arthur that evening by the C. P. R., but, as the train did not stop at Wabigoon, we were obliged to spend the night at Ignace, and go on by the local next morning. On arriving at Wabigoon three hours late, we were delighted to find the Galatea still waiting for us. A telegram from Ignace had this happy result. Leaving Wabigoon at 2.30 p. m., we reached Beaudro's Landing at 6.30, and after tea took stage over the Government road (still in very bad condition) to Gold Rock. Arriving there late at night passengers found it hard to get a place to sleep. But "a friend in need," Mr. Harry Rhodes, gave us his bed over the Wabigoon Trading Company's store, and we found this very much more comfortable than the floor of the station at Ignace. Next day (Friday, July 22nd) the class was opened at the camp (H P 371) of the Twentieth Century Company, about ½ mile east of Gold Rock. The class was closed on Thursday, July 28th. The return journey was then made. I arrived at Kingston on Monday, August 1st.

Eleven places were visited during the summer, and the classes in all of these were unusually well attended. The total number in attendance was 518. The number of specimens distributed was about 16,000. As on former occasions many mineral specimens were identified for members of the classes. The conditions of life are improving in the mining camps. This is very noticeable in the food, the efforts to have good clean sleeping quarters, and the more general presence of reading matter. Managers in most cases offer every inducement to married men to bring in their families. Comfortable houses are often built for them by the company, or in some cases the company supplies the logs for houses which the men build in their spare hours.

A feature of the work during the summer of 1904 was the lectures on geological, mining and kindred subjects, illustrated by lantern slides. The lantern used was a portable acetylene generator and lantern manufactured by D. T. Thompson and Company of Boston. It was found possible to take it with us to the most out of the way places. The lectures were uniformly well attended, and were always listened to with the greatest attention. A larger collection of slides should be provided for this work.

BANNOCKBURN PYRITE MINE

This mine is situated about two miles south of the village of Bannockburn. There were thirty-five on the pay roll, and of these thirty-three attended the class, with an average attendance of twenty-five. The acetylene lantern, purchased for these classes, was first brought into use here to illustrate a number of lectures given at the close of each days's study of the mineral specimens. It answered the purpose admirably, and four lectures were given on geological and mining subjects. The class was held outdoors at 6 p. m., when both shifts were at the mine. This was found to be a very convenient arrangement for this place, as the men boarded in many cases at farm houses some distance away and preferred to have the class before going home to tea. The attendance was remarkably good, and the intelligent questions asked showed that the men were appreciative. A quantity of pyrite was collected for future use.

On May 5th I drove to the lead mine of the Ontario Mining and Smelting Company, about two miles north of Bannockburn. The manager, Mr. H. E. Gamm, kindly allowed me to box up a large quantity of the beautiful galena for use in the summer classes. Here also a little marcasite was collected, and a number of specimens of galena covered with anglesite. The vein is narrow but of solid galena, with beautiful cleavage. It was worked by another company for several years, and the dump is now being profitably jigged. There is a good crushing and concentrating plant, and a reverberatory smelter. A blast furnace is being built.

On May 6th I drove to Eldorado and collected hematite, specular ore and quartz geodes coated with hematite crystals. On May 7th I walked to Shaw's farm about a mile west to see a copper pyrite prospect, which has been opened up for several years.

OLDEN ZINC MINE

Here much trouble had been experienced from water which came in through a large water course. This had been partially cemented up, and the foreman, Mr. T. Flynn, was confident that the stream, which flowed only in wet weather, could be completely checked by careful cementing. The shaft had been sunk to 160 feet when it was flooded out. In the meantime good ore was being raised farther east on the vein. The seconds accumulated since mining began were being hand-jigged, and a clean product obtained. There were fourteen men on the pay-roll when the class was held. Here also the hour was made 6 p. m., and found to be very satisfactory. The class was held out doors, and the lectures in the sleeping camp. Both were attended by a number of people from the farms in the vicinity. A special lecture was given one evening for the farmers and their families. The total attendance at the class was thirty-three, with an average attendance of twenty-five. Sixty-five attended the lectures, which were illustrated by about 300 lantern slides.

RADNOR IRON MINE

The manager, Mr. D. J. McCuan, met us at Eganville and kindly provided transportation to the mine, about eight miles in a southeasterly direction. The company was completing a good wagon road from the mine out to Caldwell on the Canada Atlantic railway. The miners at the Radnor are mostly drawn from the surrounding farms, but a few familiar faces were noticed of old Lake of the Woods men. There were thirty-three men employed, and they attended the class and lectures almost to a man. On May 24th a number of people drove to the mine from Eganville, Caldwell and other places in the neighborhood. Mr. T. Davis, of Eganville, brought a large number of specimens for identification, including molybdenite, graphite, corundum, feldspar, calcite, hornblende and sphene. A special lecture on crystals and crystallization was given to these visitors at 4.45 p. m. Twenty-five were present. The total

attendance at the class was forty, and the average attendance twenty-eight. The attendance at the lectures was about the same. Our stay at the Radnor was made particularly comfortable by the kindness of the manager and the chemist, Mr. C. M. Campbell, B. Sc.

CRAIGMONT

Here we were received cordially by the manager, Mr. D. G. Kerr, who had our boxes transferred, and made us his guests during our stay in the corundum region. There were about 150 men on the pay-roll, but most of them spoke little or no English, and many of the English-speaking miners lived at some distance from the mines. These difficulties made it impossible to organize a large class. The meetings were held in one of the large dining rooms (Dennison's) near the large new mill which had just been completed. The total attendance was about sixty, and the average attendance twenty-four. Many men who could not attend the class got complete named sets of specimens with such explanations as could be given in a short time. One man (Quod) came from Quodville, fifteen miles away to consult us about specimens of pyrrhotite and graphite. He had seen the notice of the classes in the newspapers.

HAILEYBURY

The discovery of nickel, silver and cobalt ores five miles to the south of this town, on the line of the Temiskaming and Northern Ontario railway, had stimulated interest in minerals, and the opportunity to study them practically and systematically was particularly welcome. A few leading citizens engaged the Orange Hall as the place of meeting. The population of Haileybury is about 600, but there is a large floating population of lumbermen and railway men. Prospecting was going on vigorously around the new discoveries, but the difficulties encountered were serious, owing to the heavy blanket of moss and gravel. Several of the prospectors walked every day distances of five or six miles to attend the class and lectures. There was a total attendance of about eighty-five, and an average attendance of thirty-eight. Many sets of minerals were given to men who could not attend the class. Prospectors showed specimens of galena, copper pyrite, and magnetite found in the neighborhood. Copper pyrite has been discovered on Fernholm's farm about two miles south. On June 8th I walked to Cobalt station (the name proposed by Prof. W. G. Miller for the new mining camp) in the company of Mr. Earle (of New York), buyer of ores, the Russels, engineers, Galbraith, division engineer, A. Ferland, proprietor of the Matabanick hotel and part owner of the smaltite vein, S. Ferland, prospector, and Hebert, discoverer of the native silver vein (No. 3). An incident of this trip is worth recording as illustrating one of the dangers of a prospector's life. As some of the party were walking towards the railway construction camp they noticed a falling tree crash down across the middle of a small tent. On examination S. Ferland was found inside, but unhurt! He had moved to one end of the tent just as the tree fell. On June 11th Professor Sharp (late of Morrin College) drove over from his farm near New Liskeard and took me back, a pleasant drive through the woods. There is a small outcrop of magnetite and hematite near Professor Sharp's house. June 13th was devoted to collecting specimens of niccolite, smaltite, and native silver, in connection with which mention should be made of the generosity of Messrs. Ferland, Timmins, Le Heup, Chambers and Darragh, who gave us a free hand among their valuable properties. We enjoyed the hospitality of Professor Miller's camp and the company for one evening of a dozen prospectors.

NEW LISKEARD

On Monday, June 6th, Mr. C. C. Farr took us from Haileybury to New Liskeard in his gasoline launch, thus avoiding a journey over a road almost impassable after the

long rains which had prevailed. There we met Mr. John Armstrong, and arranged for a class to be held in the Orange Hall, which was engaged for the purpose by the council. Professor Sharp, Rev. Mr. Pitts, and Mr. McCamus gave assistance which was much appreciated. The next day Mr. Bain, taking the lantern and the necessary mineral specimens, drove to New Liskeard and opened the class. The attendance was large and enthusiastic at both class and lectures. At the close of the work there, a number suggested that a more extended course should be given next year. The total attendance was about eighty, and the average fifty-one. Thanks are due the authorities of the Presbyterian church for the use of their building one evening when the Orange Hall was not available.

CREIGHTON MINE

Here we were the guests of the manager, Mr. George Sprecher. The class was held in a new log house, which proved comfortable for the purpose. There were about two hundred men on the pay roll, but only about forty of these were English-speaking. There was a school attended by about thirty children. A resident physician, Dr. McGonigle, had been added to the staff. A considerable village had grown up, many of the men having brought in their families. There were two general stores, and the daily train to Sudbury affords easy communication with the outside world. Altogether, the Creighton is being made a first-rate permanent mining camp. The total attendance was about forty, and the average attendance twenty.

MASSEY COPPER MINE

The class was held in the old log office, and was attended much better than last summer. The men were seated on rough seats improvised on the verandah while receiving instruction on minerals. When this was completed, the class moved into the darkened office for the lantern lectures. There were twenty-four men employed at the time of our visit. The total attendance was about thirty, including some men from the Hermina mine about two miles west, and a few farmers not working at the Massey mine. The average attendance was fifteen. Everything possible was done by manager Joseph Errington and superintendent R. C. Barclay to assist us in making the class a success.

THE SUPERIOR MINE

Having met Mr. Frank Perry, the manager, at Sault Ste. Marie, arrangements were made to proceed to Superior station, where the company's pack wagon met us and took the luggage to the mine. Captain Philip Derry welcomed us and made us comfortable during our stay at the Superior. The class was held out of doors and the lectures in the sleeping camp. There were eighteen men employed. All attended who were not at work at the time of the class. Mr. J. L. Naylor came from Searchmont to see the mineral specimens. He got a named set and the mineral indicator. Several of the mine employees whose occupations prevented their attending the class were given sets, with such information as could be mastered in the time at their disposal. Many of the men are experienced prospectors and most are good woodsmen. In this camp the interest in both mineral lessons and lectures was unusually marked. The region abounds in small lakes, in many of which speckled trout can be caught. The woods are mostly hardwood, and very open and park-like, making walking unusually easy. The total attendance was nineteen, and the average attendance fifteen.

SUNBEAM MINE (A L 282)

Here we found Mr. Copeland, the engineer, in charge, in the absence of Mr. W Jones, mine superintendent. We were hospitably entertained during our visit at the mine. The class was held out of doors and the lectures in the sleeping camp. A 10-stamp

mine. The class was held out of doors and the lectures in the sleeping camp. A 10-stamp mill had just been completed and the stamps had begun to drop on the day of our arrival. The mill, built near the bank of the Seine river, is connected with the mine, a distance of 3,200 feet, by a horse tram, by which the ore is conveyed. As the vein dips at 50° and the shaft is vertical for the first 68 feet, a raise was being made along the vein to the surface so as to give a straight shaft on the incline. This was nearly completed. The shaft was down 400 feet. There were thirty men on the pay roll, of whom twelve were non-English. Most of those of foreign birth attended both class and lectures. They included Finns, Swedes and Italians. Some of those of foreign nationality spoke English very well; others very imperfectly. All attended the class. The total attendance was thirty-one, and the average attendance twenty-three.

The difficulties of transportation are very marked in the case of this mine, making the cost of getting in supplies almost prohibitive.

LAURENTIAN MINE

This is a new prospect, being developed by the Twentieth Century Company. It is about half a mile east of Gold Rock on H P 371. Work was begun in November 1903 on a vein of well mineralized quartz and schist, striking about northeast and dipping at about 75°. The vein has been traced eastward to 298 and westward to the Big Master. At the time of our visit the shaft was down 125 feet and at the first level (80 feet) about 50 feet of drifting had been done. A crosscut had been made to a second vein about 20 feet to the eastward. Several other veins have been located on the property, including one which is claimed to be an extension of the Jubilee vein. The buildings included a temporary hoist house, a large and comfortable sleeping camp, a good dining camp, and three dwelling houses for the staff; also office, stable, store house, and power house. In February the stamp mill and other buildings at the Twentieth Century mine were dismantled and brought to the new location. Work is now being pushed on the foundation for the stamp mill and concentrating plant. The concentrates may be treated by cyaniding. Some very rich masses of ore have been taken out.

About two miles northeast, near the end of Mud lake, is the Volcanic Reef mine (S 40), near the Little Master, and owned by the Twentieth Century Company. It is a small quartz vein, with iron pyrites and shows of gold. A shaft has been put down 100 feet, and camp buildings were under construction. Thirteen men were employed.

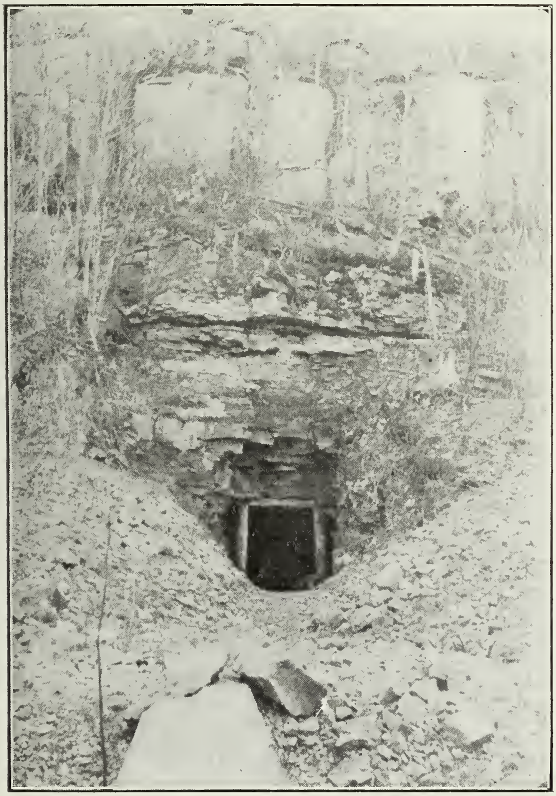
The class was held at the Laurentian, but several of the men walked over from the Volcanic Reef. As in the case of most of the mines visited this summer, the class was carried on comfortably out of doors. The lectures were given in the new sleeping camp. The total number in attendance was forty, and the average attendance twenty-two.

Both properties of the Twentieth Century Company were being developed under the management of Mr. Dryden Smith.

MINES OF WESTERN ONTARIO

BY W. E. H. CARTER

In the mining of gold, for which the western portion of the Province has been chiefly noted, results have been somewhat disappointing. The number of properties working has not greatly decreased, but the energy expended thereon has. The reasons most apparent for this state of affairs have been so frequently touched on in these reports that they need not be again gone into. Suffice it to say, that if capital were



McConnell's Iron Claim, Animikie Range. Tunnel in hematite; slate overlying, 4 to 5 feet, diabase laccolites on top.

concentrated in a few good prospects instead of being dispersed among a great many small weak companies to be spent on more or less unlikely veins, the production of the precious metal from this part of the country would be greater than it is.

A number of stamp mills have within the year been erected, but as has been pointed out on other occasions with emphasis, the work done in the mine is not always sufficient to warrant such expenditure. The haste for dividends is the bane of the industry.

Interest in this western mining field has latterly been turning to other ores, chiefly iron and iron pyrites, deposits of both of which will shortly be turned into producing mines. Not much additional news can be reported regarding the iron of the Atikokan and Steep Rock lake districts, but sufficient ore is already there to ensure production on a good scale.

A few miles east of Port Arthur, at Loon Lake siding on the Canadian Pacific Railway, the long-known but unappreciated and untouched hematite deposits have been energetically explored by diamond drills and mining during the past year or two with great results. The ore in sight, both high and low grade, is estimated at a very considerable quantity. The important possibilities of all these deposits have not been overlooked, as shown by the recent incorporation of a strong company of railway and iron capitalists to erect in the immediate future a blast furnace at Port Arthur to reduce these ores.

Animikie Iron Range, upper ore bed (all ore in view, 35 per cent. Fe) R. McConnell's location, 59 B.

The strike of high-grade Bessemer hematite at the Williams mine is another indication of the resources of the region. This ore is now being smelted at the Lake Superior Corporation's blast furnaces at Sault Ste. Marie, Ont .

The straight copper deposits are also receiving a fair share of attention, and by the perseverance of a few owners we may shortly see a number of profitably working mines, a thing unknown since the Bruce mines were in active operation. It appears very likely that a smelter will be established to handle these ores at Sault Ste. Marie, Ont., since it was shown at the Victoria Mines plant that they could be reduced, and under proper conditions, at a profit. Should the results of concentration by the oil process now under way at the Massey Station mine prove as successful as appears likely, it will bring many of these idle low grade prospects into the market.

The production of nickel (with combined copper) progresses with greater results than ever. Not only has the largest company more than doubled its capacity, but the other two concerns are making preparations for a resumption of mining and smelting in the immediate future. Ontario no longer nearly equals the output of nickel in other countries—it leads the world, and by a large margin.

By the finding of the extraordinarily rich silver-cobalt ores in the Temiskaming district last year, one more proof of the possibilities of the Province has been given. In this region also important iron, iron pyrites and arsenic deposits have been discovered, some of which have been under development for a considerable period.

As a result of this general activity in a power-consuming industry in the Sudbury and adjoining areas, four water falls have been or are being harnessed for the generation of electric energy, purchasable by anyone. This coming year will probably see greater substantial activity in mining centres in Ontario than ever before, which cannot but have its effect in bringing prosperity to all other associated enterprises.

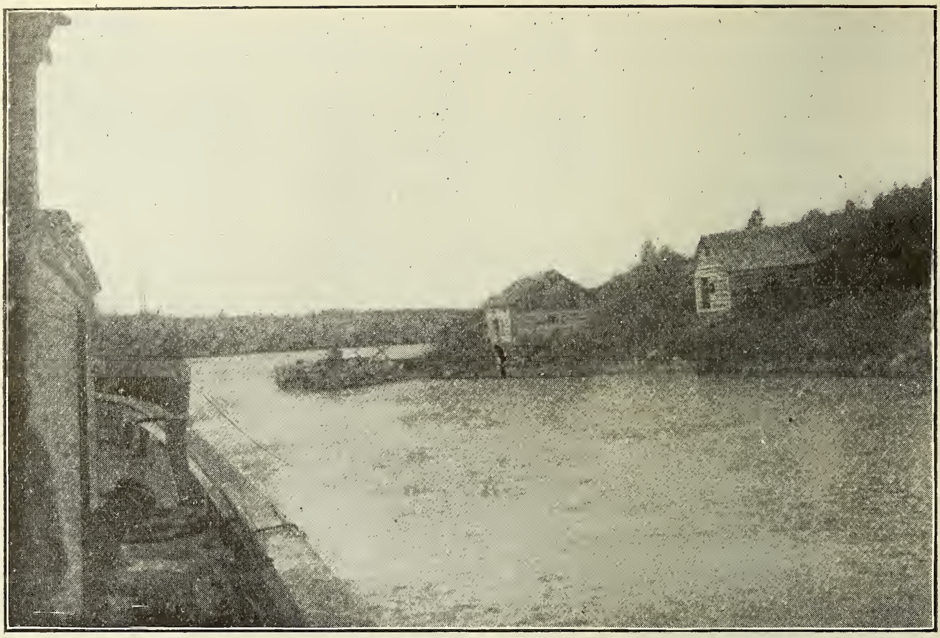
GOLD MINES

Bully Boy Mine

From Mr. Chas. Brent, of Rat Portage, it was learned that during September, 1904, the mining plant consisting of boiler, hoist and pumps, etc., intended for the Nino mine, and which has lain at Whitefish rapids for some time, was purchased and

The Damascus Gold Mining Co., Limited, Shoal Lake, bird's eye view.

removed to the Bully Boy mine, Camp bay, Lake of the Woods, where it will be set up and mining re-commenced, it is hoped shortly. Descriptions of this mine have appeared in Reports of the Bureau of Mines, Vol. VIII, pp. 60-61, 276; Vol. IX, p. 51; Vol. X, p. 73.



Ash rapids, connecting Shoal lake with Lake of the Woods; showing obstruction to navigation when water is low.

Golden Horn mine, showing mill buildings.

Cameron Island Mine

The 10-stamp mill, referred to in the last Report as under erection is about completed. Mining is to be resumed in the spring of 1905, according to a director's report. The company is now known as the Damascus Gold Mining Company, the president being Mr. Joseph Fowler, of Buffalo, N. Y.

Golden Horn Mine

During the past year and to the date of inspection, 2nd October, 1904, mining development dropped off in part, while a stamp mill was being erected. The shaft remains the same depth, namely 255 feet. The first level west drift is now connected with the old shaft, affording good ventilation to that part of the mine. The second level remains unchanged. Third level; the crosscut south at 16 feet in the west drift, was continued to 285 feet, and although it has struck an auriferous quartz vein in the face, there still remains about 50 feet to go, it is estimated, before encountering the first vein outcropping in this direction on the surface.

The shaft house has been raised to 37 feet to the sheave, to allow of dumping into cars on an elevated trestle road, running across to the stamp mill bins. This new mill building lies about 40 feet east of the shaft house and measures 22 by 62 feet plan, by 46 feet high, and contains two one-stamp Merrall's mill batteries, plates, and a Wilfley table, a 6 by 7½-inch jaw crusher, and the other usual accessories. Milling was to commence immediately of the ore dumps and what ore could be stoped out from the first level up.

A proper thawing and preparation house has been erected for the dynamite.

The management remains unchanged. The employees number fourteen, shortly to be increased to twenty.

Sultana Mine

The perseverance of the few men who have latterly furnished the money for the continued exploration of this pioneer mine has been rewarded by the location of more pay ore, on which the mill has been running most of the year. Since last inspection about a year ago the underground work has been as follows: main shaft, 560 feet deep, or 15 feet below the eighth level, with timbering complete to the eighth.

First level: the 40-foot crosscut N. E. from 130 feet S. of main shaft, which connected with an air shaft in No. 2 vein (E. of the No. 1 or the main vein), is now driving N. along No. 2 vein from this air shaft and is 34 feet in length to date, following a narrow band of quartz. From this point a drift was run at a former period to the S., 250 feet in length, but only local pockets of ore were met with.

Second level, north drift: at 12 feet N. a short drift has been started E. to intersect the No. 2 vein at 60 or 70 feet and the Galena vein at about 200 feet; but this work is postponed until a future time. South drift: at 500 feet S., in the long drift through country rock connecting the big stope with the Crown Reef vein, which drift cut away to the E. of the main or No. 1 vein, a crosscut has been driven W. 98 feet, intersecting No. 1 vein at 37 feet in. On this drifts run N. only 10 feet on account of the mixed quality of the ore, but S. 75 feet, and in the latter the ore is being stoped out. The stope measured 30 feet length by 40 feet high, by 8 feet average width.

Fourth level, south drift: at 500 feet S., underneath the corresponding crosscut in the second level, a crosscut has been run W. 98 feet, intersecting No. 1 vein at 62 feet. Drifts on the vein extend to the S. 10 feet and the N. 71 feet on a narrow band of quartz, the ore shoot pitching to the N. and not yet having been reached. At 750 feet S. on the main level another cross drift W. 80 feet took out some ore in an intersecting vein called the Fissure vein.

Seventh level: at 30 feet in the north drift a winze has been sunk to the eighth level, and a little ore stoped out.

Eighth level: this runs N. 30 feet, then E. 34 feet, and again N. 21 feet, and at end of the E. 34 feet turn connects with the seventh level winze, enlarging into a small stope. Near the face of level another winze goes down to 50 feet deeper, all on No. 1 vein. It appears from this new development, that after passing a disturbed area beneath the fault at the seventh level the vein comes in again without having suffered an appreciable displacement. The reason that not much ore has yet been reached in these new lower workings, (seventh and eighth levels) is put down to the fact that all the ore shoots dip to the N. Further development in this direction will, it is thought, strike a continuance of the pay ore. There is also reason for believing that the unexplored portion of the vein from the big stope south may produce additional ore shoots.

The surface and mining and milling plants are unchanged. Mr. J. Johnson is superintendent, employing twenty-one men.

Combined Mine

No visit was made to this property since all mining was suspended in February, 1904. S. Pinchin, the superintendent, informed me that a force of fifteen men were rebuilding the two-mile railroad from the lake to the mine, after the completion of which a six-drill air compressor was to be installed, and mining resumed. At the last inspection the workings measured as follows: Incline shaft 101 feet deep flattening from 22° dip N. to nearly level, and then dipping more steeply again. Size of shaft is 7 by 9 feet. A level was made at 75 feet depth with a N. E. drift 166 feet and a little stoping done therein. From here and the shaft dump 37 tons of ore were milled in July, producing gold to the amount of $10.50 per ton, according to the superintendent. A 40-foot steamboat has been purchased for the use of the company.

Baden-Powell

As outlined in the last Report, the former main open trench on the vein has been made the site of the main shaft. This has been timbered solidly through the cut and waste rock filled in around it. This shaft is now 98 feet deep, 6 feet by 9 feet in size, and inclining 67° W. A level was made at 60 feet depth with drifts N. 17 feet and S. 50 feet. Hoisting is done by bucket on skids and a duplex cylinder single drum hoist engine and 20 h. p. boiler in an adjoining shed. Ventilation is provided by a wooden box or pipe and steam injector.

A 5-stamp mill nears completion on the N. side of the island some 400 feet N. of the shaft, the ore to be trammed across. The mill consists of the usual plant of gravity stamps, plates, feeder and 7 by 10-inch jaw crusher, with the power furnished by a 40-h.p. return tubular boiler, and a 25-h.p. horizontal engine.

A new dwelling house has been erected on the west side of the island beside the office. The owners and management remain the same, the force numbering twelve at date of inspection, 5th October, 1904. Some instructions were given for the completion of the shaft timbering, and for the safe handling of the dynamite.

Pioneer Island

The property by this name comprises a small island mining location McA 245, and lies about one-third of a mile N. E. of the Grace mine, and one-half mile N. W. of the Golden Eagle. The owners are the Northern Light Mining Company, but shortly the property will be transferred to the subsidiary Pioneer Island Mining Company, Buffalo, N. Y. Mr. N. Higbee is superintendent with at present a force of but five. Some work was done a few years ago, and now since the resumption of operations this sum-

mer, a new small camp has been built, and the ore pit 20 feet deep squared out for timbering and continued sinking. The workings are on the south end of the island.

The vein deposit fills a contact between granite on the east and green trap on the west, and consists mainly of iron pyrites and quartz, the former in great abundance and massive. The gossan weathered surface portion is said to pan gold. A very small percentage of chalcopyrite may also be seen. The vein is traceable from the shore inland probably 400 feet, having widths at the few openings varying from one to five feet. The water lot between this and the mainland and an adjoining location thereon are to be included in the holdings of the new company.

Grace Mine

Sinking continued in the main shaft to a depth of 55 feet, reached about the first of the year, when all mining was suspended. This means that but 27 feet of sinking has been accomplished as the result of another year's work. The lower or new portion of the shaft was partly filled with water, but no new developments in connection with the ore body were apparent. The shaft was being timbered into two compartments preparatory to resuming mining. The other workings remain as before. At the foot of the hill, close to the lake shore, foundations have been prepared for a power house and plant. The employees numbered four. A new engine has been fitted into the company's launch.

Eldorado

A new corporation, the Eldorado Mining Company, incorporated under Ontario laws, has taken over this property from the former owners, the Northern Light Mining Company. The president is Walter D. Green, secretary, W. A. Barnhart, and superintendent, N. Higbee. Mining recommenced in June 1904, after a period of inactivity, the force now numbering eight. A description of the auriferous quartz vein appears in the last Report of the Bureau, and also an account of the development to that date. The shaft is now 95 feet deep, and timbered with a ladder-way and skid road for the bucket. The level at 70 feet depth runs S. W. 53 feet. An open head frame covers the shaft, and from this the hoist rope continues 100 feet or so away to the new hoisting plant beside the small 2-stamp mill. This plant comprises a 25-h. p. boiler and a hoist engine.

The first level drift is to continue along the vein S. W. for about 150 feet to meet an intersecting vein at that point which strikes N. 18° E.

No milling was done this year, but it was the intention to start on this ore in a few weeks' time.

Redeemer Mine

Operations during the past year have been active, but were mainly confined to the surface, in the erection of a stamp mill. The management is in the same hands, with a force increased to twenty. The shaft has been sunk to a depth of 235 feet, but with no lateral work whatever, which makes the present erection of treatment works somewhat premature. Hoisting is still done by bucket. This should be replaced by a safer means, such as a skip or cage, with the depth the shaft has now reached. The timbering of the new portion of the shaft has yet to be completed, and instructions to this effect were given.

The mill is situated 80 feet N.W. of the shaft, and contains 10 stamps, with all accessory plant except vanners, supplied by the Jenckes Machine Co. To tram the ore over, the shaft house has been raised to a height of 36 feet, boarded in and a level trestle road constructed to the mill.

A proper powder-thawing house has been built in a suitable place. A dry-room for the men has yet to be put up. An office has been added to the camp. Milling will commence as soon as the plant is completed this fall.

Redeemer gold mine, vein 75 feet east of shaft.

Redeemer gold mine, shaft buildings and stamp mill.

deal Mine

The shaft has this summer been continued down to a depth of 89 feet vertical; it is 7 by 10 feet in size, and timbered with a collar only. But at the date of inspection mining had again ceased, and the small force of four was constructing roads to outlying points for development. The delay is due, according to the superintendent, A. J. Herrington, to lack of cash. All mining has been done by hand, no machinery having yet been acquired. Instructions were necessary for the completion of the timbering in the shaft, and care and safe thawing of the dynamite.

Gold Coin Mine

This is a new property in the Dryden area, and comprises the south half of the north half of lot 6, concession 1, Van Horne township, half a mile from the boat landing, and on the Government road recently constructed to these properties, and due north of the Redeemer mine a short distance. The owners are the Gold Coin Mining Company. Mining commenced in April 1904, and the shaft has since been sunk 55 feet vertical and 7 by 10 feet in size, all by hand work. No one was there at the time of my visit in October 1904, operations having been suspended.

The vein is of quartz, striking east and west with vertical dip through a country rock of greenstone, in which it lies as a lenticular deposit with defined walls. It varies from 14 inches to 4 or 5 feet in width, and contains a small amount of copper and iron pyrites.

Queen Alexandra

The following information respecting this new property was obtained from T. James, the contractor for the mining done. No inspection was made, as the mine had just suspended operations. The location, H W 270, adjoins the King Edward near Carlton and Trout lakes, a short distance west of Lower Manitou lake. A shaft was sunk 85 feet deep, vertical, and 6 by 10 feet in size, on a quartz vein. Machinery consisting of a boiler and hoist, are on hand, but have not yet been set up. A 2-unit Tremaine steam stamp mill was erected and some 18 tons of the ore treated, producing $16.00 per ton in gold. This work was done between February and September, 1904 There is also a small camp of several buildings and a steamboat. F. Bolton was superintendent and representative of the English syndicate which has control of the property.

On the adjoining King Edward locations no further work has been done during the year.

Twentieth Century

All work closed here in November 1903, and in February 1904, the entire plant was dismantled and taken up the lake to the company's new properties, the Laurentian and Volcanic Reef mines, where it is being again erected. The sawmill was, however, left to cut lumber for the fresh ventures. From the superintendent, Dryden Smith the following measurements of the underground work done since my last inspection of a year ago were obtained: shaft, 389 feet deep (49 feet increase). First and second levels unchanged.

Third level: the stope in the west drift was carried up to the second level about 10 feet wide by 55 feet long.

Fourth level: west drift 19 feet wide with crosscuts from the face S. 73 feet and N. 85 feet. At 63 feet in the N. crosscut No. 2 vein was struck and followed to the W. 2 feet.

Laurentian Mine

This new property was inspected on 9th October 1904. It comprises mining location H. P. 371, of 52 acres area, situated about half a mile by a new road west of Gold Rock P. O. The owners are the Laurentian Mining Company, 43 Tremont St., Boston, Mass., and Toronto, Ont., incorporated under the laws of Ontario. The president is Anthony Blum, secretary, John Molath, and mine superintendent, Dryden Smith. The force of miners and surface men numbers twenty-one. This company owns other locations in the vicinity, which are H W 248, 252, 255, 256 and 257.

Operations commenced in October 1903, and since then there has been erected a power house, dynamite magazine, oil shed, machine and blacksmith shop, assay office, dry house, cook camp, sleeping camp, office, three separate dwellings and stables. Building operations are not quite complete on all of these. Foundations for a stamp-mill have also been put down, and all the mining and milling plant (20 stamps) from the Twentieth Century mine has been transported hither. It is to be hoped the several veins will develop into merchantable bodies of ore.

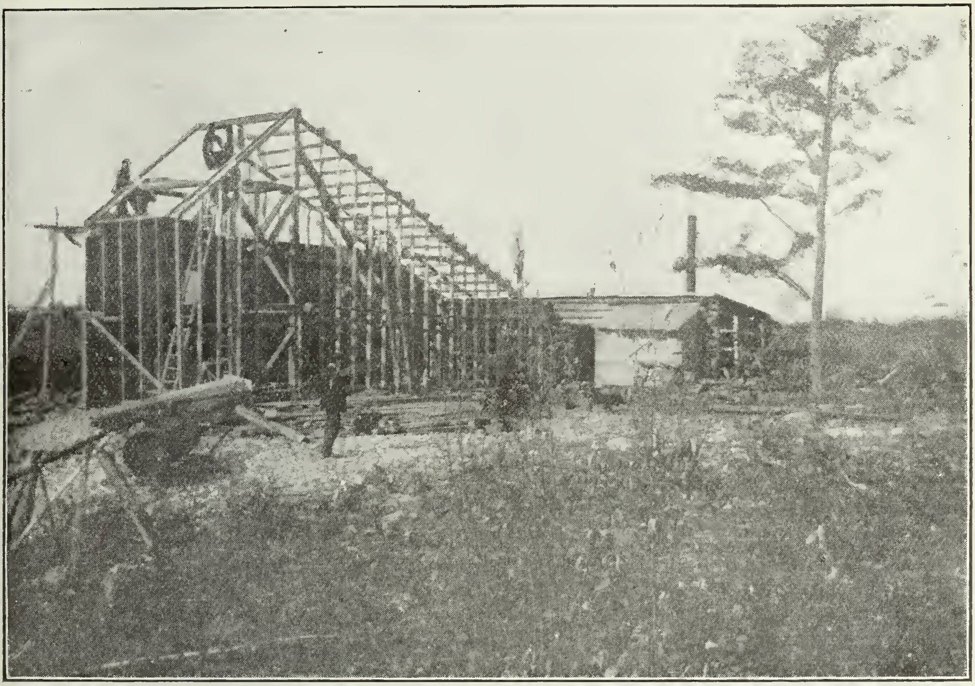
The one shaft has reached depth of 220 feet, inclining about 80° E., and is 7 by 11 feet in size. The only level is at 80 feet depth, with drifts N. 18 feet and S. 43 feet. From the face of N. drift a crosscut runs E. 22 feet; and at 7 feet in the S. drift, another, 17 feet W. for a pump station. In addition to this, the surface of the veins has been stripped at several places. The shaft has a collar and temporary head frame, but no timbers below this, and no ladders below the level. Instructions were given to put the shaft in safe condition by complying with the Mines Act regulations, and to prohibit riding in the bucket. Hoisting was done by a temporarily placed boiler and hoist engine and bucket in skids. Other instructions were necessary for the care and safe handling of the explosives.

The sinking has followed a small vein of dark quartz, which in places produced some showy free gold specimens. On the surface two other veins run parallel to this at 15 feet and 18 feet east of the shaft, and still two more at 50 feet and 150 feet west of it. The first two or three near the shaft may be found to connect, but the others appear as quite distinct deposits. They are all more or less lenticular in character, and lie in and with the strike of the greenstone country rock, which is N. E.-S. W.

Volcanic Reef

This property is operated by the same management as the Laurentian mine, namely, by Mr. Dryden Smith, with a force of fifteen men, and the owners are the Volcanic Reef Mining Company, Boston, Mass., and Toronto, Ont. President, Anthony Blum, and secretary, John Molath. The mining location under development is S 40, but the company also owns H P 377, S 39 and S 41 in the same neighborhood, namely at Mud lake, just east of the upper end of Upper Manitou lake. A mile and a half wagon road has been constructed by the company from the Laurentian to this mine as a continuation of that from Gold Rock. S 40 adjoins the Little Master property, one of the veins (No. 1) on which continues through and forms that which is here under development. It is of quartz, lying in and with the trap formation, and therefore lenticular, and a foot or so in width. From the outcrops on the top of the hill, 168 feet above Mud lake, and 600 feet northerly therefrom, or the same distance northeast of the Little Master workings, the shaft is being sunk, 130 feet deep to date, 8th October 1904, vertical, and 6 by 9 feet in size. A level has been made at 100 feet depth, with drifts N. 19 feet and S. 23 feet. Timbering has kept pace with the sinking, with the expectation of installing a cage shortly. At present hoisting is done with bucket, and a small hoist operated by compressed air, brought by 3-inch pipe from the power house on the lake shore, 1,400 feet distant. The machinery at this latter plant consists of a 50-h.p. tubular boiler and a 3-drill Rand

air compressor. At the mine a new shaft-house will shortly be completed to replace the present temporary arrangements. For the camp two large log houses have been built, and a stable. Some carelessness existed in the care and thawing of the dynamite, for the remedying of which instructions were given.



Volcanic Reef gold mine, shaft and buildings.

Giant Mine

The point of operations has again been shifted, but this time back to the original place on H. W. 75. The shaft and other development work on H. W. 185 is reported to have not given sufficient pay rock to warrant further expenditure. The mining plant has in part been transported over to the lake shore below the old tunnel, and set up with a one-stamp Nissen mill, with which some small test runs on the ore were made. The other camp is still in use however. In June 1904, sinking was resumed in the old 18-foot shaft under and past which the tunnel was driven during 1901-02 to a length of 100 feet. The shaft has just broken through into the tunnel at a depth of 60 feet on its incline of 80° N. W., and intersects the latter at 55 feet in. The vein fills the shaft, 6 feet wide, having defined walls, and being composed of quartz, calcite and chlorite, with a fairly high percentage of iron pyrites.

The stamp mill is connected with these workings by about 250 feet of surface tram road, the plant consisting of a 1-stamp battery, the 18-h.p. mine boiler, engine, feeder, crusher and plates.

P. Paulson remains in charge with a force of six.

Little Master

Development has continued steadily since last inspection under the same management, and with a force of twenty-five men. The main or No. 3 shaft is now 175 feet deep, and timbered most of the way.

First level, 152 feet deep; west crosscut, 175 feet; east crosscut, 130 feet, with a drift S. 20 feet at 105 feet in. A No. 3 Cameron pump unwaters from this level. Hoisting is still done by bucket, but this is operated from a new power house 60 feet S. E. of the shaft. Herein have been installed a new 2-drill Rand air-compressor, the same hoist and another 65-h.p. locomotive boiler. This last was in a very unsafe condition, necessitating instructions for its abandonment. A large new boarding house is about completed, the lumber for which is cut on the premises in a sawmill owned by the company.

The plan of development entails crosscutting from the underground levels to the four more or less parallel veins additional to the one (No. 2 vein) that No. 3 shaft is sunk in. The No. 1 vein lies about 200 feet N. W. of No. 3 shaft, and forms in its N. E. extension the Volcanic Reef mine vein. Shafts Nos. 3 (main) and 2 are sunk in the same No. 2 vein about 300 feet apart. Veins Nos. 3, 4 and 5 lie to the S. E. of the main shaft, all within about 200 feet distance and nearly equally spaced.

Paymaster Mine

This newly opened prospect comprises mining location H W 20 of 83 acres area, and adjoins the Big Master locations to the southeast. It is owned by the Northern Development Company, president, J. E. Burns, and secretary, E. D. Soudan, with offices at 107 Majestic Building, Detroit, Mich. Operations commenced in the fall of 1903 with R. J. Elliott as superintendent. A vertical shaft has been sunk 100 feet deep with a drift N. W. 20 feet from the bottom. Hoisting is done by bucket and small hoist, and a 25-h. p. boiler in an adjoining hoist house.

A couple of neat camp buildings have also been erected.

The shaft started down on one of two lenticular quartz veins about 30 feet apart, each from 18 inches to 2 feet wide where exposed on the surface, and dipping a few degrees to the S. E. with strike about N. E.-S. W. The country rock is the green schist of this district. Work had just ceased at the time of my inspection, 7th October, 1904, but has since been resumed, according to report.

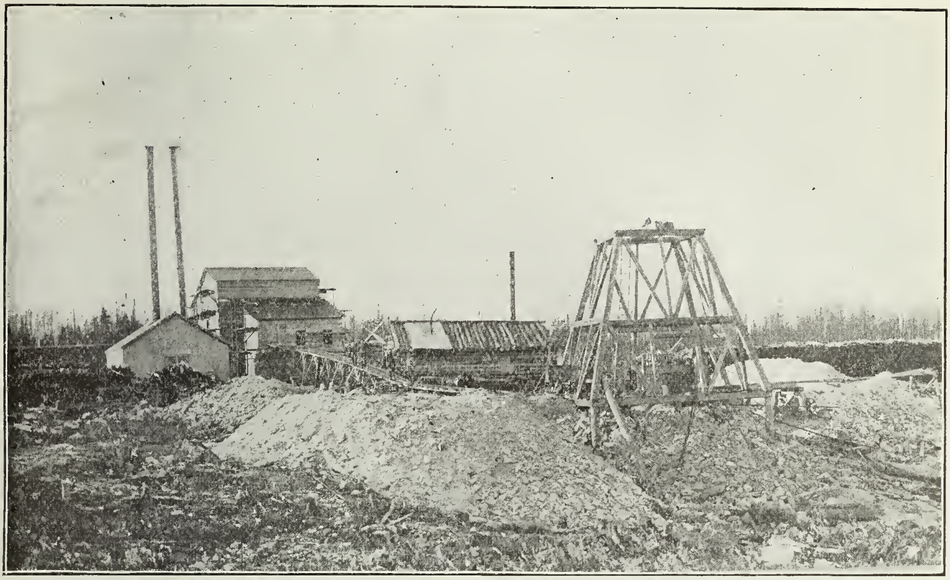
Big Master

Owing to financial difficulties this mine has lain idle since the first of the year. The bondholders recently foreclosed on the former owners, the Interstate Consolidated Mineral Company, bid in the property, and formed themselves into the Big Master Mining Company, licensed to operate under the laws of Ontario, with president Benj. Hammond. The offices of the new concern are at Fishkill-on-Hudson, N. Y., and Gold Rock, Ont. W. Shovells is still in charge, and with a few men has commenced renovating camps and machinery, and strengthening the head frame structure over the shaft with the intention of shortly resuming mining. Additional mining plant in the way of pumps, air drills and hoist may be installed.

According to the office plans the ore shoot in the west vein has been found to widen and lengthen respectively from 2½ feet by 30 feet on the surface to 8 feet by 156 feet on the second or 185-foot level, and 9 feet width in the winze below this point, and to have shown an average value of $17 per ton. The East vein or shoot, so far only opened out along the first or 85 foot level, has a length there of 140 feet, and a width of 12 feet, with an averge assay value of $8.35 per ton.

St. Anthony Reef

On account of the lateness of the season and because practically no mining had been done since the last inspection of this property in 1902, no visit was made on this trip. But later from Mr. J. S. Steele, manager, it was learnt that mining was resumed towards the end of the year, No. 1 open cut being deepened to water level



St. Anthony Reef Gold Mining Company, Sturgeon lake, showing mill building and head gear of No. 2 shaft.

View from Dawson's Cottage (English River Gold Mining Company), looking west.

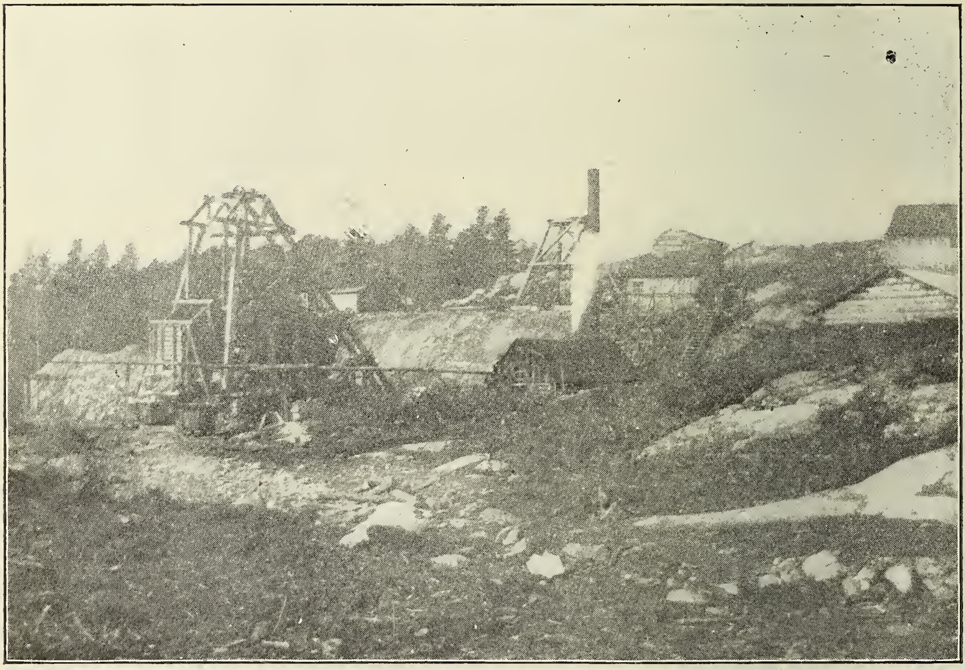
(lake level), that is to 44 feet deep at the breast, and Nos. 1 and 2 shafts being connected by a drift on the underground level. Stoping had begun at this latter place.

During the past year, also, a 10-stamp mill was taken in and erected, a sawmill to furnish the lumber necessary, and a complete mining plant of boiler, hoist, air-compressor, drills and pumps. It was expected that the mill was then in operation, as sufficient ore for some months to come already lies at the dumps.

The employees number twenty.

Sunbeam Mine

This is the old A L 282 property. The owners and management remain the same, but the force of men has increased to forty on account of the enlarged scale of operations. Some additional mining locations have been acquired adjoining or in the vicinity of A L 282, as follows: H P 623 to 626, and X277-8-9, 590-1 and 614. A 10-stamp mill has been built on X614 about three-fourths of a mile distant from the



A. L. 282 or Sunbeam gold mine.

mine on A L 282, and the two connected by a surface tram road operated with horse cars. The milling plant includes 10 stamps of 1,050 lbs. weight, plates, 9 by 15-inch jaw crusher, a 40-h.p. horizontal engine, and in an adjoining building a 40-h.p. boiler. The pump is stationed on the lake shore 200 feet distant. Treatment of the ore commenced in July 1904, and has continued steadily to this date of inspection, 13th October 1904.

At the mine considerable work has been accomplished. The upper 76-foot vertical portion of the shaft has been abandoned and the incline continued straight to the surface for the better operation of the skip. The new shaft head gear combines small ore bins and chutes, from which the tram cars are loaded for the mill. The shaft has reached a depth of 410 feet on the 43° incline N.

First level, S. W. drift, 135 feet (30 feet increase) with a stope 65 feet long by 25 feet high by 6 feet wide.

Second level: in the N. E. drift there are two stopes, one 30 feet long by 8 feet high by 6 feet wide, and the other 35 feet long by 12 feet high by 6 feet wide; S. W. drift, also two stopes, one 30 feet long by 12 feet high by 6 feet wide, and the other 50 feet long by 15 feet high by 6 feet wide.

Third level: in the S. W. drift is one stope 25 feet long by 6 feet high by 6 feet wide.

Shakespeare gold mine; shaft, tunnel and power house.

All mining is done by hand drills. Ventilation depends on the natural air circulation, which will soon have to be aided, if the working places are extended. A new hoist house has been built on the flat beside the boiler house, and contains a new 25-h. p. hoist engine.

A L 200

A short account of this property was given in the last Report of the Bureau on pages 71 and 72. According to one of the officers of the company a little more mining has been done since, consisting of stripping the vein and crosscutting it at about 1,000 feet N. E. of the shaft. Two log camp dwellings have also been built, and it is hoped to recommence development actively this fall.

Shakespeare Mine

Three inspections were made of this mine during the summer of 1904, the second one occasioned by a serious fatal accident whereby six miners lost their lives. A report on this fatality appears in another part of this volume. All operations were

suspended for a month or so after the accident, but since that time have continued steadily since the inspection of last year.

The tunnel reached a length of 75 feet crosscutting the formation northwesterly. At 65 feet drifts were run 43 feet S. W., and 37 feet N. E., with in the latter a crosscut from the face 17 feet S. W. At its face the tunnel connects with shaft at a point 53 feet down. The shaft is in all 95 feet deep, with at 90 feet depth a crosscut S. E. 38 feet. It is timbered into a bucket-way and ladder-way. At the mouth of the tunnel stands the power-house, with 40-h. p. boiler, 3-drill Ingersoll air-compressor and hoist engine. The blacksmith shop adjoins.

From the shaft house a surface tram road runs 200 feet across the ridge to a box chute dumping on to the crusher floor of a new stamp mill now under erection at the foot of the cliff on the flat in the N. side. The plant contains 5 gravity stamps, Frue vanner, plates, 7 by 10-inch jaw crusher and feeder, and a 35-h. p. boiler and 10 by 12-inch horizontal engine, and it is expected will be in operation in a month or less.

At the date of the last inspection, 27th October 1904, Mr. James McKenzie was superintendent, with a force of eight.

Avon Mine

The property by this name is controlled by a syndicate composed of J. C. Foley and associates, and comprises an area of 360 acres in Shakespeare township adjoining the Shakespeare mine, made up as follows: N. half lot 4, concession I; S. half of lot 4, concession II; and the S. E. quarter of S. half of lot 5, concession II. Mr. J. C.

Avon mine, compressor plant. Tunnel in hill to right.

Foley is in charge, with a force of fourteen men. The present mining work is exploratory, consisting of surface cuts, and the tunnel 200 feet long to date, driven S. E. across the same rock ridge or hill in which the Shakespeare workings lie, and at about one-quarter of a mile farther N. E. A compressor plant has been erected near the tunnel, containing a 50-h. p. boiler and a 3-drill Rand air-compressor. The camp buildings number three.

Instructions were given for greater care in storing, handling and thawing the dynamite.

Lucinda Mine

This property consists of the N. half of section 11 and the S. half of section 2, Fenwick township, situated near Goulais bay, lake Superior, and is reached by road or trail from Searchmont, Algoma Central railway, some 35 miles north of Sault Ste. Marie. A shaft has been sunk 65 feet deep and in addition some surface stripping has been done. A 45-ton Huntingdon mill was installed this summer, but after a few days run all operations were suspended.

The property is owned by the Lucinda Gold Mining Company, Sault Ste. Marie. Mich., secretary, Chas. M. Dysinger, and president, F. M. Dale.

IRON MINES

Williams Mine

Considerable activity has marked the development of this property since the last inspection of a year ago. At 30th October, 1904, the shaft had reached a depth of 200 feet, and was carefully timbered and divided into two compartments, for ladder-way in one and bucket-way with guides and cross head in the other. A level has been opened at 200 feet depth with drifts S. E. 20 feet and N. W. 74 feet at 30 feet. In the latter a crosscut runs N. E. 42 feet; and at 35 feet in, another S. W. 86 feet. All drilling is done by hand. A new blacksmith and carpenter shop had just been completed, the old one to be converted into a dry room. Ventilation is provided for by a 12-inch pipe with steam jet suspended down the shaft and along the level to the working faces. From February to May 1904, 1,500 feet of diamond drilling was done, the five holes being all bored from the bottom of the shaft, serving to guide the subsequent development outlined above. One hole inclined 70° northeasterly, passed through 16 feet of clean hematite at 322 feet depth. With the opening of the level a body or vein of clean, solid ore was struck 4 feet six inches in width, and this extends through the drifts. Nothing further was met in the N. E. crosscut, but in the S. W. one a series of ore bodies was cut through about as follows, and in addition to the body in the main level: from the drift S. W., 16 feet slate, 2 feet mixed ore 4 feet clean ore, 3 feet mixd ore, 7 feet clean ore, 9 feet slate, 7 feet mixed ore, 8 feet clean ore, 30 feet to face in black schist. The aggregate width of clean ore is 19 feet, and of lean ore 12 feet.

With the stoping out of some of these bodies shipments will, it is expected, be made during the winter, and for the purpose a wagon road is to be constructed around the N. E. shore of Loon lake, about two miles in all, to connect with the Algoma Central railway at Wilde station. Mr. C. C. Williams is manager, and employs a force of eighteen men.

Helen Mine

With the removal of the financial difficulties of the Lake Superior Corporation in the spring of 1904, this mine resumed operations, and has since been producing and shipping at the rate of about 1,000 tons of ore a day. Mr. R. W. Seelye is superintendent, and employs a force of between 150 and 160 men. The largest portion of the output of the mine is going to the United States, filling contracts made previous to the erection by the company at Sault Ste. Marie of its own blast furnaces. A fair amount has however already been stocked at the blast furnace dock at the Soo. It brings a high price in foreign competition on account of its value as a mixer with the prevailing soft ores of the States.

No more ore is now raised from the open pit, but all is milled to the underground levels and hoisted out by way of the shafts. There are two of these 100 feet apart. No. 1 is used for development purposes, and No. 2 for hoisting ore, and both are about 200 feet deep. The pit floor, 90 feet below the surface, counts as the first level; the second is at 168 feet depth. On this, drifts run approximately at right angles to one another, undermining the ore body, and from suitable points raises have been made to the pit floor 80 feet above, down which the ore is underhand stoped or milled from the pit to the second level, to form large stock piles. From these the desired quantities can be trammed to produce the best grade mixture of ore. These mill holes have been so located that each produces one of the several distinct grades of ore. According to Mr. Seelye, the first grade is hard compact red hematite, 60 per cent. iron and over; the second porous but hard brown limonite, 57 to 58 per cent. iron; the third, soft brown limonite, 53 to 54 per cent. iron. The grades low in iron are on the other hand freer from phosphorus and sulphur, so that by judicious mixing an ore of the following average content can be maintained:

	Per Cent.
Iron	61.40
Silica	4.50
Phosphorus	.087
Sulphur	.085
Water	3.75

When shipping, the skips dump the ore direct into the rock crusher at the top of shaft house, whence it drops into the 50-ton ore cars to be hauled at once to the ore docks in Michipicoten Harbor. In winter the ore will be stocked underground, and not on ore piles in the open as formerly. No. 2 shaft is now sinking to open out a third level to repeat the operations on the second.

The surface plant has been partially remodelled by lowering the shaft house and crusher some 36 feet, and installing a new large double drum hoist and the two air compressors (14- and 6-drill respectively) in a new power house on the bared banks of Boyer lake now pumped out. A new battery of four boilers in the same building supplies power for the entire workings. The rest of the plant remains the same as before.

Instructions were given for certain changes in the place and method of thawing the dynamite, and also for greater safety in its general care.

Preparations have been made for hydraulicking and pumping out the mud which overlies the 60-foot deposit of iron pyrites to a thickness of 30 to 35 feet in the bed of Boyer lake. This mud will have to be removed before the pyrites can be handled.

COPPER MINES

Massey Station Mine

Inspections were made of this mine twice in 1904, one in June and the other in October. On the last occasion a change had been made in the staff, Mr. H. W Hardinge being superintendent, and Mr. Barclay having resigned from treasurership of the company. The mine had been closed temporarily in July, during the construction of the oil concentrator, but had again opened at the time of my second visit. The number of employees has been increased to forty-four.

The shaft had not been sunk any deeper.

First level: unchanged.

Second level: small overhand stopes in both E. and W. drifts.

Third level: E. drift, 54 feet with overhand stope to the face 32 feet high, and ending in a raise to the second level, and connecting by winze with the fourth level.

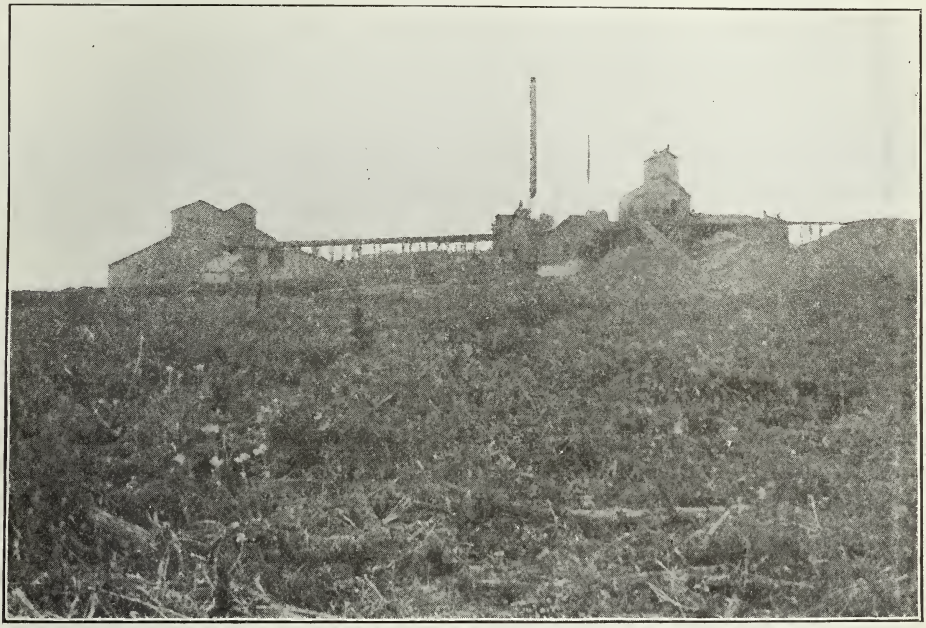
Fourth level: E. drift 140 feet with a crosscut from the face S. 30 feet, and a stope 64 feet long by 20 feet high; W. drift 243 feet, with at 141 feet in a crosscut S. 16 feet, and a stope 55 feet long by 55 feet high, terminating in the raise to the third level.

Fifth level: E. drift 52 feet, and W. drift 30 feet.

Sixth level: E. drift 17 feet, and W. drift 35 feet.

Seventh level: E. drift 115 feet, with at 50 feet in a crosscut N. 50 feet; W. drift 37 feet, with at the face crosscuts N. W. 85 feet and S. 15 feet.

The shaft partition has been put in to the fourth level, according to subsequent advice from the manager.



Massey Station copper mine, oil concentrator and mine looking west.

The rails were laid on the side line of railway from Massey station this spring, and the machinery and plant for the new concentrator brought in. By October the plant was completed and in operation.

The accompanying illustrations will give an idea of the size of the building. The ore treatment consists of first wet concentration on a Wilfley table of the fairly coarse pulp, and subsequent separation of the chalcopyrite out of the finely pulped remainder by taking advantage of the affinity of this mineral for oil. The plant consists of a Krupp ball mill, a Wilfley concentrator, a tube mill and a 2-unit (50-ton) Elmore oil plant. The engine operating the whole is supplied with steam from the adjacent mine boiler battery. The first runs with the plant are giving good results.

Hermina Mine

Development has progressed actively at this property during the past year, with at present a force of 15 to 20 men. It was inspected on three occasions during 1904 to see that several instructions regarding its safe operation were carried out. The last visit was made on 28th October 1904. Mining has during the year been confined practically to one place at the southeast end of the property, by sinking a shaft 202

feet deep, vertical, and 7 by 10 feet in size, with the first level at 90 feet depth, on which a crosscut runs E. 25 feet, then turning S. 40 feet, and a second level station just being opened. The timbering for a bucket-way with crosshead and guides, and a ladder-way was being completed to the bottom. The shaft follows down a vein of almost clean chalcopyrite from one to two feet wide, which lies in a green trap.

A solid head frame has been erected over the shaft, and a short distance away a power house containing the mining plant of a 50-h. p. boiler, 6-drill Ingersoll air-compressor, duplex cylinder, 3-foot drum hoist engine and pumps. The blacksmith shop adjoins, but the same camp is in use about three-fourths of a mile to the west, where a new office has been built.

The wide vein at the N. W. end of the lots received some further attention by sinking a 10-foot pit out of the surface crosscut mentioned in last year's report.

A satisfactory dynamite thawing-house has been added, and another separated shed is to be used immediately for storing the oil.

Eagle Copper Mine

A short account of this mine was given in the Twelfth Report of the Bureau, page 101, under the heading Goulais Bay. In addition to the S. W. quarter of section 14, the company also control the N. W. quarter of section 14, the S. W. and N. W. quarters of section 23, and the S. E. quarter of the S. E. quarter of section 15, all in Vankoughnet township, aggregating 600 acres.

Most of the mining has been done on the S. W. quarter of section 14, consisting of a shaft 55 feet deep, vertical, and 6 by 11 feet in size, with, at the bottom, a crosscut running S. 37 feet, and then E. 66 feet. At 40 feet in this last 60 feet another crosscut was driven S. 18 feet. At 200 feet S. E. of the shaft a tunnel enters the hill for 90 feet in a S. E. direction. The vein is composed of quartz carrying chalcopyrite and galena, with values in gold and silver. A mining plant has been installed consisting of a 14-h.p. boiler, pump, a steam drill and a hoist engine. The camp is made up of two dwelling houses.

The above information was obtained in October, 1904, from Mr. A. G. Terrill, who contracted for the mining done, no inspection being made because of the suspension of operations a few days previous.

Superior Mine

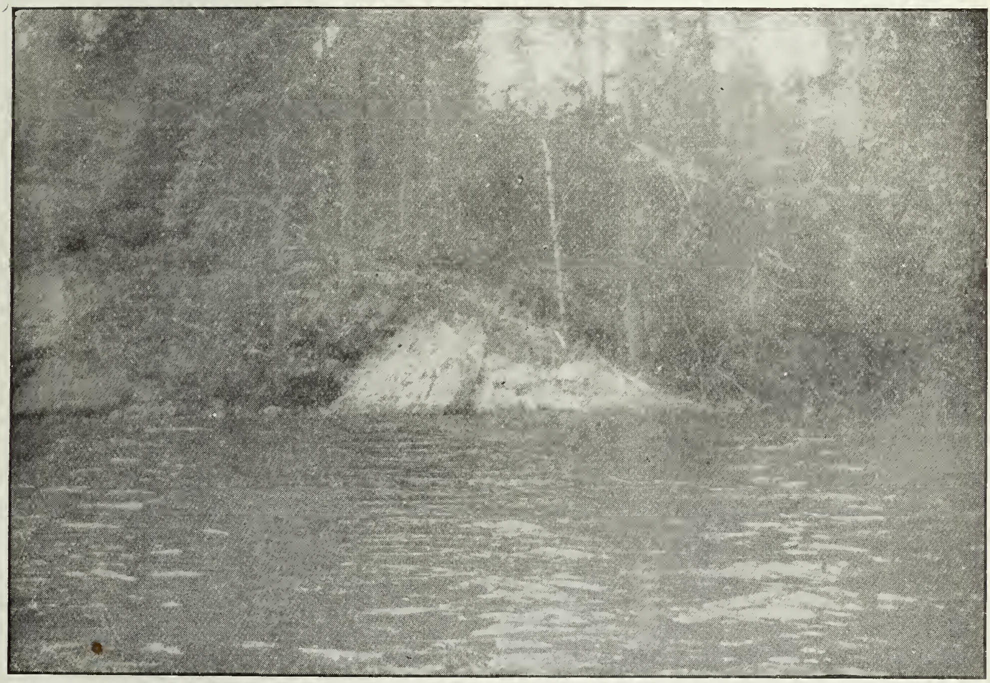
This property suspended development a few days before my arrival in the district, and no inspection was therefore made; but from Mr. F. M. Perry, manager, it is learned that all work has during the year been confined to No. 6 shaft, which has reached a depth of 260 feet, with the first level at 100 feet depth and drifting thereon N. W. 25 feet and S. E. 25 feet; and the second level at 200 feet depth, with drifts N. W. 25 feet and S. E. 25 feet. The surface plant remains unchanged. The reason given for the stoppage is that the mine has reached the point where it is advisable to prosecute development on a larger scale with increased mining plant and facilities of transportation, such as a side line of railway from the Algoma Central railway, and also where some means of treating the ore must be decided on. It is a question either of concentrating at the mine or shipping the ore to Sault Ste. Marie to be smelted at a customs plant, which may be erected there, or possibly of both. As soon as the future plan of operations is decided on the owners intimate their intention of resuming work.

WHISKEY LAKE COPPER AREA

The Whiskey Lake area, so-called from the presence within its boundaries of a fairly large lake of that name, is included at the present time within four townships, each six miles square, and known as Nos. 137, 138, 143 and 144. These are contiguous in the form of a square, whose southern boundary lies two townships north of Sheddan

and Lewis, which border on the north shore of Lake Huron. The lower end of Whiskey lake is distant about fifteen miles due north of Cutler, on the Canadian Pacific railway, Sault Branch, from where one may reach the lake by canoe, up the Serpent river waters. Lumbering operations, however, practically close this river for navigation until the fall of the year. The usual route followed is by a roundabout road 33 miles long from Massey Station, farther east, northwesterly through the townships of Salter and Tennyson, and township No. 130 to the east side of Whiskey lake, after which all travel is by canoe through the lakes and rivers which abound in the region. Another road of about the same length, but in a worse condition for travel, goes northeast from Spragge, to the west of Cutler, arriving at Picard's lake. At this point the canoe is taken, passing up Whiskey creek, about three miles in length, and thence into Whiskey lake.

Most of the townships in this district have been under timber license to lumbering firms for thirty years or more, with authority to cut the pine and other trees thereon, and the existence of these valuable timber interests has operated to discourage pros-



H. E. Long's quartz-copper vein; outcropping on west side Corner Lake, Timber Berths 137 and 143.

pecting or mining, which would tend to expose the timber to danger of loss by fire. Most of the townships have been cut over once, a number of years ago, but the timber then too small to take has grown in size, and in certain portions of the limits is now merchantable. Where the lands have been denuded of their timber this obstacle to mining does not, of course, exist.

The occurrence of copper in the area has been known for a number of years, but not until recently have other than the original one or two finds been made. These new deposits have proved to be unusually continuous, as a result of which the locators have taken up considerable areas of land, some of which have been surveyed, and the rest simply applied for, pending the opening of the district for mining. The excellent specimens of ore sent out also gave the appearance of worth to the discoveries, warranting the present short examination of the field.

The district has several characteristic features in which it differs from the lower land to the south, amongst these being the large number of lakes, long and narrow for the most part, separated by high rocky hills and connected one with the other by typical mountain streams. Although the hills do not rise much over 300 feet from the lakes at the foot, they are unusually precipitous and strewn with rock debris. The rocky nature of the country is frequently hidden at a distance by the heavy growth of stout, healthy trees of both hard and soft woods.

For a couple of miles or so north of Massey Station the road passes over quartzites intersected at intervals by dikes of greenstone, probably diorite, and then into a stretch six to ten miles wide composed entirely, as far as could be observed, of the igneous rocks, granite gneiss and diorite, the last intersecting the other in narrow or, more frequently, extensive eruptions. At Whiskey lake the quartzite again appears, and here, as in the belt to the south, it is broken up by a series of more or less parallel intrusions of diorite, having a course east and west and vertical dip. Where observed, the width ranges from 100 feet to as much as half-a-mile. In texture the diorite is usually medium-grained, granular and green in color, although along its contacts with the quartzite this disappears in an alteration towards a darker compact schist.

The quartzite, in texture, composition and color, varies considerably, but in the main is of rusty white, clear quartz of medium grain. From this it ranges through a pinkish arkose with the feldspar in fair abundance towards a fine-grained grayish rock also felspathic; and on the other hand towards a quite coarse rock, almost entirely quartz in composition, having somewhat the appearance of a conglomerate from the presence of embedded stones measuring as much as six or eight inches across. These large inclusions are, however, composed of practically identical material.

Along the east shore of Whiskey lake, where also the eastern boundary line of the townships in this area runs, granite outcroppings appear on some of the hills, but whether they are of intrusive origin as well as the diorite, or merely outliers from the Laurentian rocks to the north, was not determined, no copper veins having yet been discovered on that side of the lake and area.

An examination of the different mining locations shows three distinct classes of veins or ore deposits, according to their characteristics, but all appear traceable in the first instance to faulting or fracturing, subsequent to the solidification of the greenstone ejections.

Campbell's Island

On Campbell's island, near the centre of Whiskey lake, and at the falls at the head of the lake one and the same class of vein occurs. It consists of lenticular quartz fillings in blocky green schist, the quartz carrying galena and iron and copper pyrites in irregular pockets, which are quite small and unimportant in value where exposed by the few open cuts and strippings. A sample from one of these openings on the vein at each location gave by assay only traces in gold, but from $1.00 to over $3.00 per ton silver, according to the quantity of galena present. The amount of copper was too small to need a determination.

Campbell's island has an area of about 160 acres and rises very steeply to a height of 185 feet above the lake. It consists of a mass of diorite, and through the face of a bluff of this on the south side, at 125 feet above the lake, the quartz vein outcrops, striking about N. W.-S. E., with a dip of thirty degrees N. E. The vein can be traced for about 225 feet in all, having a width of four or five feet for 75 feet N. W. of the one opening, but pinching out to narrow stringers in the remaining 150 feet in the opposite direction.

The other location referred to as at the head of Whiskey lake, takes in, as applied for, the land on both sides of the 100-yard stream and falls (20-feet drop) which empties Bear lake into Whiskey lake. The lenticular quartz vein lies on the east side of the stream and was traced back east from the water's edge 300 or 400 feet, with widths of two to six feet. The strike is east and west and dip about vertical.

This class of vein lies well within the interior of the greenstone bands, and has no apparent connection with the contact disturbances to which are due the most important class of ore body described hereafter.

The Peyton Location

The class to which the second variety of vein belongs is yet doubtful. It will probably be found to have lenticular characteristics. Only one example is so far known, and that on mining location W R 94, called the Peyton location, on the west side of Whiskey lake and southwest of Campbell's island. The vein outcrops at the shore, mostly under the water, and cannot be traced for more than 100 feet altogether. Apparently it pinches out inland, as nothing is to be seen of it in the rock bluffs back of the shore. It lies in the quartzite with vertical dip, and a strike N. 70° W. well within one of a series of bands of this formation alternating in a N. and S. direction with other bands of greenstone.

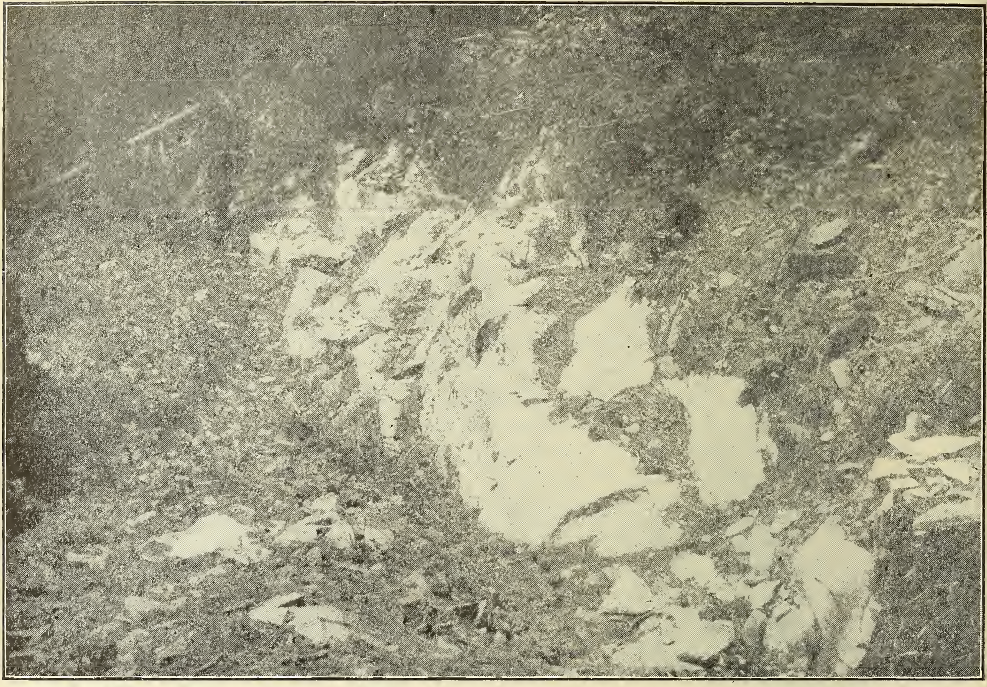
Quartz and chalcopyrite compose the vein and ore. Of this from the exposure on the shore a small amount was raised by open pit which ran high in copper content. In a 25-foot shaft sunk a short distance back from the lake the quartz body breaks up into a few smaller stringers with less copper. The small amount of work done, with the meagre surface exposure is insufficient to give any idea as to the continuity of either the vein or the copper values therein.

The veins of the third or remaining class have been found more frequently than either of the others, and from their unusual continuity along unvarying lines of strike, and the generous distribution of fair to merchantable quantities of copper at all points where uncovered, they undoubtedly form the most important deposits of copper ore in the area. They constitute fillings of quartz and chalcopyrite along faulted or merely shattered zones of the greenstone, always either in or quite close to its contact with the quartzite. The greenstone or diorite side of these contacts evidently marked the main lines of weakness in the rocks of the area, since no other disturbance approaches the prominence of this.

Where a clean fault was made the vein has all the characteristics of a true fissure deposit. The walls are often slickensided and lined with more or less gouge, being in such case well defined. Most of the gangue consists of quartz, especially where the vein has narrowed down, the only other rock being trap, which is interbanded through the quartz in greatest quantity where the vein is widest. The brecciated ore bodies, which follow lines or zones of fracture rather than of faulting in the diorite, are composed mainly of the trap itself in angular masses, both large and small, cemented together with a much smaller quantity of quartz and chalcopyrite. The walls in this case are rather indefinite; the ore will probably be found to quickly decrease in copper content as the undisturbed rock on either side is approached.

The strike of these copper veins, like that of the contacts of the diorite and quartzite they follow, is most often a few (about ten) degrees south of west, but it varies locally as much as 45 degrees. The veins have a width of three or four feet to over twenty feet. The copper occurs as chalcopyrite, and constitutes practically the only sulphide present, iron pyrites being visible in the gangue and the walls alone. The chalcopyrite is both finely disseminated and in large masses or bands, sometimes a foot wide. As very little work has been done it was not possible to fairly sample the veins for their copper content; but it will be neither too much nor too little to say that they are very good prospects.

THE LONG TOM LOCATIONS



H. E. Long's quartz-copper vein, stripped on north side McCool lake, Timber Berth, 137.

H. E. Long's quartz-copper vein stripped on W. R. 91, Timber Berth 137.

One of these veins is especially interesting. It was discovered and located by Mr. H. E. Long, who has since traced it for nearly three miles, and for a further distance of two or three miles more on either side he found similar outcroppings of apparently the same deposit. The locations covering it have since been surveyed and filed with the following numbers, from east to west, W. R. 118, 114, 113, 119, 91, 115, 116, all in the northwest corner of timber berth 137, and W. R. 116, 117 and 126, adjoining in timber berth 143. For about half their total length these locations border on and include most of the land under the waters of McCool and Corner lakes. The property is now known as the Long Tom, and aggregates about 1,760 acres. H. E. Long and Jas. J. McFadden are the two applicants. The vein lies along the contact between diorite on the south and quartzite on the north, but entirely in the diorite, and has been uncovered and trenched at numerous points along and near the north shore of McCool lake, and at the prominent outcrops on both sides of Corner lake. The fissure now filled by this vein follows an almost straight course S. 80° W.

The Reynolds Property

The Reynolds property consists of mining location W R 92 at the northwest end of Whiskey lake and between it and Bear lake and the short stream which joins the two. It lies in timber berth 138, about a mile north of the east end of the Long Tom locations. Chas. C. Reynolds is the locator, and jointly with some associates, the applicant. The outcroppings and what work has been done on them in the way of a big open cut, are reached by a short trail from the bay on the Whiskey lake side about 300 feet north of the creek mouth. The vein has the same strike as the Long Tom, namely S. 80° W., with about vertical dip and at the one opening is twenty feet wide. This width seems to be maintained in the 300 feet over which it was traced under the moss. It is composed of quartz and the slightly altered hornblende country rock, closely intermixed into a dark mass, through all of which chalcopyrite is disseminated in considerable porportion, mainly in a fine state. In this case the contact of the enclosing greenstone with the quartzite lies to the south a short distance, nearer the shores of Bear lake.

The other deposits do not need any special description. One is covered by mining location W R 93, and from its position at the easterly end of the Long Tom properties may be a continuation of that vein. It is on another small lake on the east and west line dividing timber berths 137 and 138.

Another copper-bearing lode of this class was discovered a few days prior to my visit, and has been applied for as mining location Y 352, by J. A. Montague and associates. It borders on the west shore of Whitefish lake, which is about one-quarter mile west of the lower stretch of Whiskey lake, into which it empties by a swift mountain stream. It is reached by way of Whiskey lake, by a trail starting from the camp of the first vein mentioned, W R 94. The vein cuts across a mountain or high hill, which rises several hundred feet above Whitefish lake, the first exposure being 235 feet up. It lies in or near the contact btween the greenstone on the northeast and the quartzite on the southwest, striking approximately N. W.-S. E. The vein consists of a coarsely fractured zone of the trap cemented with quartz, with the chalcopyrite mostly in the latter. The few uncoverings show a width of about ten feet of vein material. Some stripping and other surface work was done on it during the summer.

A year or so previous to my visit to this area some similar copper veins were discovered and superficially explored farther south, probably half way between the Massey Station copper mine and these Whiskey lake deposits, and reached by the same road from Massey Station. This may indicate a considerably larger copper-bearing area than has so far been defined.

NICKEL-COPPER MINES

With the resumption of ore reduction in the new smelter plant of the Canadian Copper Company, the reopening of the Mond Nickel Company's mines and smelter at Victoria Mines, the exploration by diamond drills of the Lake Superior Corporation's nickel mines prior to a resumption of development, and the opening up of some smaller but new nickel prospects, the outlook for the coming year is very bright in the Sudbury nickel camps. Depending on the capacity of the market to absorb the product, the output of the high-grade matte should be much greater in 1905 than ever before. The Mond Nickel Company's nickel refinery in Wales has just been enlarged to double its former capacity, so that there need be no cause for another suspension of production at their Canadian mines and works for lack of an outlet for the matte.

The nickel ores of the Province have been added to by the new finds of cobalt-nickel arsenides and silver near Haileybury in the Temiskaming district, although for a time the probability is that these ores will be treated out of the Province.

Visits of inspection were made to these mines in June and October, 1904.

The mines of this area, nickel, copper and any others, will shortly have within reach all the electric energy they can consume. Besides the development of the High Falls water power for use by the Canadian Copper Company's mines and works, three other water power companies will shortly have electric energy for sale.

Power house of the Sudbury Power Company, McPherson falls, Vermilion river, Creighton township.

One is on the Wahnapitae river about three miles south of Wahnapitae station, C. P. R., where the head of water is 53 feet, the maximum power 5,000-h.p., and the amount to be used or developed 2,500-h.p. Another is at McPherson's falls, on the Vermilion river, on lots 11, concessions I and II, Creighton township, about ten miles due south of Larchwood, C. P. R. main line, and about sixteen miles west of Sudbury. The head of water here is 25 feet and the capacity of the power 3,000

h. p., of which about 1,200-h. p. is to be now made available. The Sudbury Power Company is undertaking this work. In addition to these two which are simply for the sale of electric power, there is another source of a limited supply at the Spanish River Pulp and Paper Company's pulp mill near Espanola, where a drop of 60 feet on the Spanish river is now under control for the development of 10,000-h. p., and at some future date, as desired, of the total capacity of 22,000-h. p.

CANADIAN COPPER COMPANY

Two set-backs were encountered by this company during the year by the burning down first of the Ontario Smelting Works in February, and in June of the West smelter. By leasing the plant of the Mond Nickel Company at Victoria Mines the problem of refining the low grade matte product of the West smelter was overcome. But with the destruction of this latter plant all production work had to cease until October, when the new smelter commenced operations.

The management has been active in incorporating the most modern economic ideas and practices into all parts of the works, and many changes and improvements are noticeable over the conditions of a year ago. New plant is bought from time to time, such as locomotives and other rolling stock, roadbeds improved, new lines laid out, and new buildings erected at different points to increase the capacity or efficiency of the various parts of the operations at mines, roast yards, machine shops, foundry and so on, not forgetting the beautifying of the town of Copper Cliff by an occasional coat of paint.

The only changes in the staff are the appointment of P. R. Bradley to the position of smelter superintendent, and the resignation of Mr. Baird, and of Mr. R. Taylor as smelter foreman. In June the employees numbered 1,082. This is somewhat reduced now with the completion of the smelter plant.

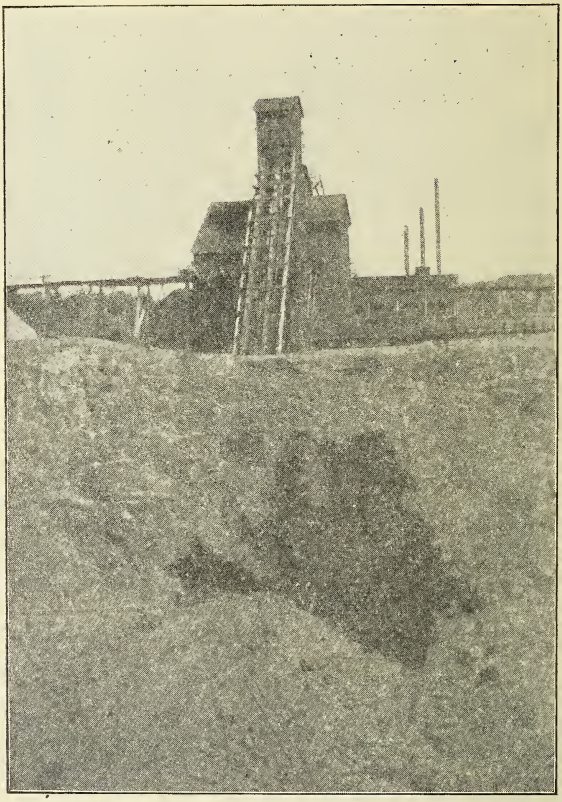
After several preliminary trials the new smelter began its continuous run about the end of October, 1904, for the production in one operation of high grade Bessemer matte. The last Report of the Bureau contains a general description of this plant; in detail the different parts are as follows: Two blast furnaces, capacity 550 tons of charge each per day; three Bessemer converters in place, revolved electrically; four settling wells; slag pots on double truck cars; electric travelling crane to handle converters and matte pots; in the power house, a battery of four water-tube boilers with water purifying system; condenser plant; three blower engines, one for the converters and two for the blast furnaces; two electric generators of 250 k. w., each connected to high speed Corliss valve engines; two lighting dynamos of 75 k. w., belt driven by high speed Peerless engines; and many pumps and other accessory machines.

There are no important changes in the roast yards. No. 3 contains about 100 heaps of various sizes, and No. 1 about 65, comprising about 175,000 tons of ore, about all the company care to have lying idle preparatory to smelting, since half this is sufficient to insure a steady smelter supply. For this reason not many heaps have been built latterly.

Creighton Mine

Mr. Geo. A. Sprecher was in charge of this mine, with a force of 177 men in June and 100 in October. The pit now measures 250 feet by 300 feet plan, by the same depth of 60 feet. The shaft has been extended down to the second level, 140 feet deep, with double skip road and ladder-way; a drift runs from the bottom S. 70 feet, and a raise from there to the pit floor, down which the ore is now in part stoped. This latter working place has a diameter of 50 feet, and forms a pocket for storing large quantities of ore ready for hoisting. The output from the pit and second level has averaged about 500 tons a day, with a maximum of nearly 1,000 tons a day. The surface is being stripped to the S. and S. E., preparatory to the extension of the pit in that direction.

The mining plant is the same except that a new double drum five-ton hoist has replaced the former one. A fine manager's dwelling has been built in addition to several other dwellings for the employees.



Creighton nickel mine, looking south.

This is the only mine belonging to the company which is now producing nickel ore, all the remaining working ones having been closed during the summer and allowed to fill with water. The Creighton has such immense reserves of high-grade, cheaply mined ore that it will be unnecessary to operate the other properties, probably for many years to come.

Copper Cliff Mine

Towards the last the output of this mine amounted to only 80 tons of ore a day, which though unusually rich did not compensate, the company state, for the expenses entailed in the operation of such a deep mine, and in August 1904, the pumps and other machinery were raised, and the mine permitted to fill with water.

The last new work consisted in re-opening the bottom of the old big stope on the thirteenth level, and breaking down considerable ore from the sides and far face. Nothing worth while now remains there. After stoping out all the ore about the winze from the thirteenth to the fourteenth levels to a size of 10 feet width by 40 feet length, the same winze and then the stope were continued down about 75 feet deeper, the stope here being somewhat wider, but of the same length. The continued nickel-copper content of this ore ranged from ten to twelve per cent., mainly copper.

Vermilion and Krean Hill Mines

In January 1904, the Vermilion mine was re-opened by the Canadian Copper Company, who now have the controlling interest. It was originally known as a gold and platinum deposit, and a small stamp mill, now entirely gone, was erected to treat the ore. But after passing through the few feet of weathered surface or gossan, into the unaltered sulphides, no more free precious minerals were found, and so the venture terminated. It has always been known as a remarkably rich nickel deposit, though small and irregular, and the present development is for further exploration only. A small mining plant consisting of a three-drill air-compressor, 60-h.p. boiler, small hoist engine and pump was set up to facilitate the work. The old camp has again been made use of.

The workings comprise several small open cuts and one large one 8 feet wide by 50 feet long E. and W., by 12 feet deep. Out of the centre of this a shaft has been sunk 57 feet deep, vertical, and 7 by 7 feet in size, and from the bottom drifts run S. E. turning E., 80 feet; and W. 60 feet. At 80 feet S. E. of this shaft is another old one, now full of water, but reported to be 60 feet deep. The ore lies in an irregular contact between quartzite or arkose on the S. and S. E. side, and schists and greenstones on the N. and N. W. side, occasionally extending into the latter, in lenticular pockets and stringers more or less connected and continuous, in widths varying quickly from a few inches all the way to eight feet. Two diamond drill holes were bored near the old shaft.

This mine is reached by a two and a half mile road from Victoria Mines. About half way in it branches off to the Krean Hill property about one and one quarter mile farther north, where the company have four miners doing a little prospecting on a deposit of nickel sulphide ore somewhat similar to the Vermilion.

Other mention of these deposits will be found in Reports of the Bureau of Mines, Vol. IV, p. 36; Vol. VII, pp. 142-3; Vol. XII, p. 272.

Huronian Company

The International Nickel Company have formed another subsidiary company under the above name to develop the water power at High falls on the Spanish river, for the purpose of transmitting electric energy to the mines and works of the Canadian Copper Company at Copper Cliff. High falls is situated about four miles north of the Canadian Pacific Railway, Sault Branch, at Nairn, and about twenty-six miles southwesterly from Copper Cliff. Instead of cutting a right of way for the pole line the latter will be put up along the Canadian Pacific railway tracks to Copper Cliff. The river at the falls breaks up into several channels over a dike of greenstone, and necessitates an unusual amount of dam building. Two large dams will confine the stream into the head race, the rocky hills forming the other sides. Four smaller dams will close up other channels and a seventh in the west channel will take the overflow and be provided with a log chute. There will also be a heavy bulkhead at the end of the head race above the power house. from which four nine-foot diameter steel penstocks will descend at an incline of 85 feet in 200. All dam work is to be concrete. The present drop is 67 feet, but when raised by the damming a head of 85 feet will be attained at which it is estimated the total power will be 22,000-h. p. About one-half of this, or 11,000-h.p., will be transformed into electric energy by the present development, and the plant arranged for the utilization of the rest on short notice. A four-mile line of railroad was first of all (in the spring of 1904) constructed from the Canadian Pacific railway tracks at the new station Turbine in to the falls.

Messrs. Ross & Holgate, engineers, have charge of the work, and Mr. Geo. Revell is resident engineer. The force of workers number 300, for whom a large number of dwellings have been erected. It is expected the power will be ready for use by the end of 1905.

VICTORIA MINE

During the year since last inspection the mine remained closed. A few days prior to my visit of 26th October 1904, unwatering was commenced, the intention being to

resume ore raising as soon as possible and fill the roast yard so that by spring smelting might again begin. The smelter plant has not been idle long, however, being used under lease from February to July by the Canadian Copper Company, for raising their low grade matte to a high grade product, and also for a short time making smelter tests in the Massey Station mine copper ore. No changes of importance have been made in the plant.

Mr. H. W. Hixon has returned to take charge again, and informs me that Dr. Mond's nickel refining works in Wales have just been doubled in capacity. This will allow of immediate treatment of all matte the Victoria plant can turn out.

The Mond Nickel Company has continued mining at the North Star, which mine was under lease to it, and has had all the ore shipped to the Victoria smelter yards, where it is stocked to the amount of about 15,000 tons. It is to be smelted now.

North Star Mine

Inspections were made of this mine in June and October 1904, and it was found still working under lease to the Mond Nickel Company, with Mr. C. V. Corless in charge, and a force of from forty to forty-eight. An average of 100 tons of ore is raised per day, and immediately shipped by rail to the Victoria mine smelter. The above lease has until December to run. The open pit or trench on the ore body has been deepened to 175 feet by means of a shaft down its centre for the first 100 feet and between pillars for the remaining 75 feet. From the bottom of the shaft short drifts through these pillars lead into the stopes on either side. The E. stope extends 80 feet from the shaft and up to the surface 10 feet to 15 feet wide; and the W stope, 120 feet from the shaft and up to the surface, but higher up not more than 100 feet in length, and from 10 feet to 20 feet wide. Both E. and W. faces have reached the end of the workable ore. To determine whether or not it extends down to greater depths in sufficient widths a number of diamond drill holes are being bored.

EVANS NO. 2 MINE

This nickel prospect had a little surface work done on it a few years ago, and now is undergoing somewhat more extensive development. It consists of the following parts of lot 7, in the third concession of Snider township, aggregating 100 acres: N. W. $\frac{1}{4}$ of S. E. $\frac{1}{4}$; N. E. $\frac{1}{4}$ of S. W. $\frac{1}{4}$; S. W. $\frac{1}{4}$ of N. E. $\frac{1}{4}$; and the S. E. and S. W. quarters of N. W. $\frac{1}{4}$. The Manitoulin and North Shore railway cuts across the N. W. corner of the lot, at $8\frac{1}{4}$ miles west of Sudbury, and three-quarters of a mile east of the North Star mine. J. W. Evans of Deseronto, Ont., is owner, and J. A. Baycroft, superintendent. The employees number four. This last work commenced in August 1904, when a small camp was erected. A shaft has since been sunk 23 feet deep, with a five foot crosscut at the bottom on a small but fairly well defined zone of mixed ore in gabbro.

IRON PYRITES AND ARSENIC

Steep Rock Lake

During the exploration with diamond drill and otherwise for iron ore in the vicinity of Steep Rock lake, Western Ontario, by Messrs. Mackenzie, Mann and Company, a valuable vein of iron pyrites was discovered. This happened towards the end of 1903, and further work on it extended into 1904, but no ore raising has yet been undertaken. The locations on which it lies are A L 460 and 461 on the west side of the west arm of Steep Rock lake, and adjoining these A L 472-3-4 and 462 have also been acquired. Five diamond drill holes were sunk within a distance of 1,200 feet, showing that below the badly weathered and indeterminable surface

indications an almost clean vein of iron pyrites exists, having widths from south to north (its direction of strike) of 6, 9, 13, 21 and upwards of 12 feet. The pyrites was sand-like in the last hole, caving in on the drill rods to such an extent that drilling had to be stopped. The widest places held the cleanest ore, although all, according to Mr. J. A. Wood, the superintendent, is of shipping grade.

Development to the productive state has been postponed; and in the meantime explorations of a similar nature are being conducted at other points on the lake for further deposits.

The vein of pyrites appears to follow a fault plane in the light colored chloritic schists of the area, which badly squeezed and alterated portion of the rock it has replaced.

Another party of prospectors was conducting explorations for iron or iron pyrites in the same neighborhood, but had not found anything at the time of my visit, October 1904.

James Lake

Mining locations W S 404 and 405, 109 acres in area, are situated a short distance west of the Temiskaming and Northern Ontario railway, at Rib lake siding, nine miles north of lake Temagami, and bordering on James lake. They are owned by Major R. G. Leckie, Sudbury, and have been under development by him for the past year or so, for a deposit of iron pyrites. A small camp has been erected on the shore of James lake to house the force of five to eight men.

The ore consists of a fairly clean body of pyrrhotite on one side and iron pyrites on the other, across a total width of forty feet, and apparently lies in a contact between hornblende granite on the northwest and green schist on the southeast side with a strike northeast-southwest. So little rock is exposed on account of the uniform covering of soil and moss, that a more complete idea of the general geology of the locations could not readily be obtained. By means of a 24-foot shaft and several pits and open cuts the ore body has been explored for a distance of 400 feet. One complete cross-section, beginning on the southeast side, shows 5 feet of clean pyrites, 6 feet of rock more or less highly mineralized, 12 feet of clean pyrites, and finally about 15 feet of pyrrhotite, which is probably a fair average of the amount of each in the body. The iron pyrites are said to assay from 48 to 50 per cent. sulphur, with traces only of gold. The pyrrhotite is not thought to be of value since it carries only from \$1.00 to \$2.00 per ton gold, about 0.5 per cent. copper, and from 1 to 1 5 per cent. nickel.

Major Leckie expects to build additional camps and mine houses, increase his force and ship ore during the coming season. The proximity (one-quarter mile) to the railway will allow of very cheap transportation, a necessity to the mining of iron pyrites.

Arsenic Lake

Locations W S 13 and 14 are also owned by Major R. G. Leckie, who has had them under development for a year or more, with a force of about seven miners. They lie on a small pond known as Arsenic lake, which is one and one-half miles by road northwest of mile post 74 on the Temiskaming and Northern Ontario railway two miles north of Temagami. So far tents have sufficed, but a substantial log camp is to be built at once. The ore found here is mispickel—arsenical pyrites—filling a shear zone about 8 feet wide in the green schist of the area. Two solid, clean bands of ore, aggregating three to four feet in width lie on each side of a central lower grade somewhat wider portion, having a strike about south-southwest by north-northeast. The ore will probably be sorted into two grades when mined, on account of its irregular outline and composition, the greatest width of solid ore so far explored being only 3 feet, whereas a safe average of the whole merchantable body is about 8 feet. The clean ore carries, according to assay, \$16.63 per ton gold and silver, and

30 per cent arsenic, and the second grade not over 10 per cent arsenic. Copper and iron pyrites are also present, the percentage of copper running from 0.5 to 1.5 per cent. Stripping with open cuts has laid bare a length of 60 feet by a width of 20 feet along the ore body.

The number of arsenic deposits already discovered and opened up in this immediate area may warrant the erection of an arsenic refinery in their midst. On this same road, but much nearer to the railway, lies the Big Dan arsenic locations, found a number of years ago, but only this year explored to any extent.

CORUNDUM

Canada Corundum Company

With the gradual adjustment of the new mill to the ore and mining conditions, the scale of operations has increased at all points. Quarries appear to almost cover a very large portion of the hillside in which the ore occurs, and the mill concentrates now nearly 200 tons of ore a day, with a corresponding output of 10 to 12 tons of

Canada Corundum Company, view of corundum hill.

corundum. Certain modifications, such as curtailment, alteration or increment of various parts of the process and plant have been found advisable in the interest of increased economy and capacity, but other than this the plant and operations remain practically the same as at last inspection. Mr. D. G. Kerr is manager, employing a force of from 135 to 140 men.

A number of new buildings have been erected near the mill, including office and analytical laboratory, and in the flat opposite a small hamlet of workmen's cottages

has sprung up, the old camps being inconveniently distant now that all work is confined to this one locality.

It is expected with this complete system and plant that grain corundum of such purity will be uniformly produced as to insure a steadily increasing demand. There

Canada Corundum Company's mill.

need be no doubt about a constant supply for a long time to come, if not indefinitely, but it requires time for the trade to appreciate this superior but somewhat more expensive abrasive.

Ontario Corundum Company

This company was unfortunate enough last spring to suffer the destruction of its new mill by fire. But with unquenched energy plans were immediately prepared for another and better plant, and at the time of my inspection, 20th September 1904, this was nearing completion. A different process is to be employed, namely, dry concentration throughout. The two main buildings are the boiler house and mill. In the former a 125-h. p. boiler is installed to do all the drying by steam as well as to run the plant. The plant comprises five Blake crushers, one 9 by 15 inches, two 7 by 10 inches, and two 4 by 10 inches; two "lightning" (impact) crushers or pulverizers; two rolls; dividers; magnetic separator—the Noble; seven Hooper pneumatic jigs; a dryer; a 75-h. p. horizontal engine and electric lighting plant. The ore will be dried immediately on arrival from the mine and will remain dry thereafter.

Mining is confined to the same quarry, but from now out sorting will not form so important a part of this work, since most, if not all, of the ore will be concentrated.

A force of twenty men is employed under superintendent W. Mackie.

MINES OF EASTERN ONTARIO

BY E. T. CORKILL

GOLD MINES

The production of gold in eastern Ontario in 1904 amounted practically to nothing, although a number of gold properties were under development. The Belmont mine, which ceased operations in 1903, has not as yet been re-opened. It is very unfortunate that a mine which gave such promise as the Belmont should be allowed to lie idle. Financial men still have faith in the gold mines of this section, since two new mills were erected durng 1904, and additional companies are being formed for the purpose of developing in this district. One thing, however, is to be regretted, and this has been pointed out in former reports, namely, the large sums of money spent on the surface in the erection of stamp mills, and installation of expensive machinery, when little or no development work has been done to prove the extent of the ore body. This cannot be wholly blamed on the managers, as the stockholders think that dividends should begin to come in as soon as work is commenced.

Craig Gold Mine

The Craig property, owned and operated by the Craig Gold Mining and Reduction Company of Newark, N. J., comprises the south half of lots 4 and 5 in the third concession of the township of Tudor. It was first opened some years ago, and in 1896 a shaft was sunk on it to a depth of 100 feet. It was re-opened in 1904, and active mining work begun under the management of W. A. Hungerford.

Two shafts have been sunk at a distance of about 400 feet apart, the south shaft to a depth of 110 feet. At a depth of 60 feet a level has been run, the north drift being 280 feet and the south drift 40 feet in length. Stoping is carried on in both drifts. In the north shaft, which has been sunk to a depth of 110 feet, a drift has been run south a distance of 80 feet from the 60-foot level.

A Rand compressor plant, two 80-h. p. boilers and double drum hoist to hoist from two shafts have been installed. Two shaft houses have been built with ore bins complete, also blacksmith shop, store house, boarding house for 75 men and office. A new mill 80 by 32 feet was erected in 1904, and a Merrall 3-stamp battery, triple discharge, was installed. This is the first mill of this pattern erected in Canada, and a large tonnage is claimed for it. The present capacity is about 17 tons per day.

A force of forty-seven men is employed.

The Pearce property owned by the Cleveland Mining Company was worked for some months in 1904.

The shaft is sunk to a depth of 185 feet. Levels were established at 60 feet and 100 feet, and 320 feet of drifting was done. The air was supplied from the Atlas Arsenic Company's works, which are one mile distant. The mine was not in operation at the time of my visit, but Mr. W. A. Hungerford, manager, supplied me with the above information.

Star of the East Mine

This mine, owned by the Star of the East Gold Mining and Milling Company, is situated on lot 24 in the tenth concession of Barrie township, Frontenac county, and was in operation during the whole of 1904.

There are two veins on this property running parallel, about 60 feet apart, in an easterly and westerly direction. On the south vein three openings have been made, the deepest of which is about 30 feet in depth. On the north vein a shaft 180 feet deep has been sunk. The shaft is 18 feet by 11 feet, solidly cribbed for 25 feet, and timbered the entire depth. The first level is at a depth of 80 feet, from which drifts have been driven 50 feet east and west. No stoping has yet been done. Hoisting is done by means of a bucket operated by a duplex cylinder hoist, 24-inch drum. A boiler of 30-h. p. capacity supplies power to the hoist and to the drill. The mill, which was constructed in 1904, is situated about one-quarter of a mile from the mine. A 10-stamp battery was installed during the past winter, and now handles the output of the mine. The ore is first crushed to one inch and smaller and fed into the stamps where it is reduced so as to pass through a 60-mesh screen. After passing over the plates the pulp passes on to a Wilfley table. The concentrates, which consist chiefly of pyrites and a little magnetic iron, are saved for future treatment. A magazine built of stone with tin roof, boarding house offices, stables and some houses for men have been built.

The veins occur in crystalline limestone from four to six feet in width, dipping about 85 degrees to the south. Lenticular massess of quartz occur in the vein associated with pyrite, magnetite, actinolite, calcite and zincblende (not common). Bismuth and bismuthinite have also been found in the vein. The enriched zone is about three to four feet from the hanging wall.

IRON MINES

Radnor Mine

The Radnor mine, owned by the Canada Iron Furnace Company, was the chief producer in 1904 in the eastern part of the Province. About 2,500 tons of ore was shipped during the winter to the company's furnace at Radnor Forges, Quebec. On account of all mining being done from open pits, the difficulties met with during the winter were considerable. As a consequence, only one pit was being worked at the time of my inspection in February, 1905. This pit is called No. 7, and is situated 300 feet northwest of No. 8. These open pits are in a semi-circular form from north to south, beginning at No. 7, which is the most northerly, and following in rotation Nos. 8, 5, 6, 1, 2 and 3. These pits show that the deposit has a uniform pitch of 38 degrees to the southwest. No. 8 pit was worked during 1904, but closed for the winter for reasons mentioned above.

Diamond drilling was carried on by the company in 1904, holes being put down southwest of the openings and the deposit found to be quite uniform with depth.

No. 7 pit now being worked is 40 feet long, 30 feet wide and 15 feet deep. The ore is a coarse-grained magnetite interlaminated with gneiss. Before shipping, it is sorted into two grades: (1) middlings, carrying about 30 per cent. iron; (2) good ore, carrying about 50 per cent. iron.

It has been shown that the low-grade ore could be concentrated by means of magnetic separators. If this method should prove a success commercially, a great amount of ore which at present is worthless could be made marketable.

A force of twenty-five men was employed under superintendent D. J. McCuan.

Mineral Range Iron Company

The properties belonging to the Mineral Range Iron Mining Company, which are described quite fully in the Eleventh Report of the Bureau, were not worked to any extent during the past year. The success of the properties depends on the railway facilities and means of transportation being provided. Mr. H. C. Farnum, the manager

of the company, is now endeavoring to have a railroad built from L'Amable station on the Central Ontario railway to Barry's Bay station on the Canada Atlantic railway. This road, if built, would furnish transportation for both the iron of Hastings county and the corundum of Renfrew county.

The Mineral Range Iron Mining Company have done a great deal of work in stripping and proving their properties, and claim to be able to ship 1,000 tons of ore per day as soon as they are afforded means of outlet. Numerous assays of the ore show the ore to contain from 50 to 60 per cent. iron, from .01 to a trace of sulphur, and a trace of phosphorus.

Experiments have been made upon the ore from the Ledyard iron mine at Belmont with a view to reducing the sulphur contents by magnetic separation. Very satisfactory results were obtained, the sulphur content being lowered to one-tenth of one per cent.

In the vicinity of lake Temagami some diamond drilling was done in 1904 to explore the iron ranges of that district. Owing to difficulties encountered progress was very slow, and but little development was accomplished. It is expected, however, that further work will be done during the coming season.

IRON PYRITES

A greater interest is being taken in the development of the iron pyrites properties of eastern Ontario. The production of this mineral here dates back to the year 1900, when ore was shipped to the Nicholls Chemical Works, to be used in the manufacture of sulphuric acid. Since that time the production has steadily increased, resulting in the discovery and development of new bodies of ore ,and interesting other capital in the development of this industry.

American Madoc Mining Company

The property known as the Jarman Pyrites mine, about one mile southeast of Bannockburn, was worked continuously during 1904. At the time of inspection the employees numbered forty, A. F. Rising being superintendent. The shaft has reached a depth of 190 feet (an increase of 15 feet since last inspection.) The ore has been stoped down to the third level, below which all work is now being carried on. The north drift on the third level, which is at a depth of 175 feet, is 175 feet in length, and the south drift 90 feet. A 10-foot pillar is being left in the floor of the third level north drift, and stoping and sinking is being carried on simultaneously below this level. Dams have been constructed on the third level, in order to catch all the water from the upper workings, and a Cameron sinking pump installed. Hoisting with bucket has recently replaced hoisting with the skip.

Another property situated on lot 23 in the twelfth concession of the township of Hungerford, about one-quarter mile from the C. P. R. and near the village of Bogart, was worked by this company for some months during 1904. The development work has shown up a large body of ore. The vein runs a little north of east and dips to the south.

The depth of the main shaft on the vein is 160 feet. At the 100-foot level the east drift is run 40 feet and the west 35 feet. From the west drift a crosscut has been run north a distance of 100 feet, cutting several veins of pyrites. The two widest veins average 10 feet each of marketable ore.

A complete plant, consisting of air-compressor, boiler, hoist and rock house, is being put in, and preparations are being made for extensive mining operations.

British American Pyrites Company

The British American Pyrites Company, Limited, of Toronto, commenced development work on lot 11 in the eleventh concession of the township of Madoc on the first of October, 1904. A force of nine men is employed under superintendent E. L. Fraleck.

Considerable stripping and crosscutting was done, and a shaft 7 by 12 feet has been sunk to a depth of 60 feet, all in ore. The pyrites is very high grade, some samples running as high as 50 per cent. in sulphur; an average of about 48 per cent. is maintained by sorting out the wall rock. A well defined fahlband is here traceable for a mile. The diorite appears altered on the surface to talc and chlorite schists.

LEAD MINES

Hollandia Mine

The lead mine owned by the Ontario Mining and Smelting Company, and formerly known as the Hollandia lead mine, was actively worked during 1904. A circular water-jacketted blast furnace was installed and two carloads of pig lead produced. Considerable work was done on the surface during the past summer in stripping, proving the vein to outcrop for at least 2,500 feet. All mining work is now being carried on from No. 1 shaft, which is vertical, and has a depth of 100 feet, with drifts run for a distance of 25 feet along the vein from the shaft. Nos. 2 and 3 shafts were also worked during the year and some stoping done. The galena is here found in veins associated with calcite in a dark colored schistose rock which may be called a diorite gneiss. The veins cross the strike of the country rock.

The force consisted of fifteen men under superintendent H. F. E. Gamm. Mr. Gamm has recently been succeeded by Mr. Cushman as manager, with Mr. Ellis as superintendent.

Frontenac Mine

Further work was done on the Frontenac lead mine in 1904. This property is part of lots 15 and 16 in the ninth concession of Loughboro township, and is described in the Geological Survey report, 1866-69. One opening 40 feet deep has been made and about 500 tons of the mixed ore (galena and zincblende) raised. The vein is about 11 feet in width, and maintains its width as far as developed.

A mill test of this ore was made at the Kingston School of Mining, showing a saving of 70 to 80 per cent. of the lead in the ore with coarse crushing. As shown by the report on this test, the ore carries from 5 to 10 per cent. of lead and 2 to 4 per cent. of zinc. The concentration is best done by crushing in rolls, then passing over the jigs to get rid of the tailings. The jig concentrates run over 60 per cent. lead and are high enough in lead for shipment. What goes through the jig screens (12-mesh or under) can be passed over the Wilfley table with a fair separation of the galena, and these two operations will save from 70 to 80 per cent. of the lead in the ore. A greater saving might be made, but it is doubtful whether it would not cost more than it is worth in labor and equipment. The ore contains but very little silver, not more than one or two ounces per ton.

ZINC MINES

The Richardson zinc mine, on which development work has been being done for the last three or four years, has now reached a depth of 109 feet. A new vertical shaft is being sunk at a point 250 feet west of the old shaft. This is now down 65 feet

with 2 to 3 feet of ore in the bottom. A shaft house has been erected and boiler and straight-line air-compressor installed. A concentrating mill is also being built,

Richardson zinc mine, showing concentrating mill.

the machinery consisting of a Sturtevant crusher, rolls, jigs and tables. It is expected that all machinery will be in position by July, 1905.

COPPER MINES

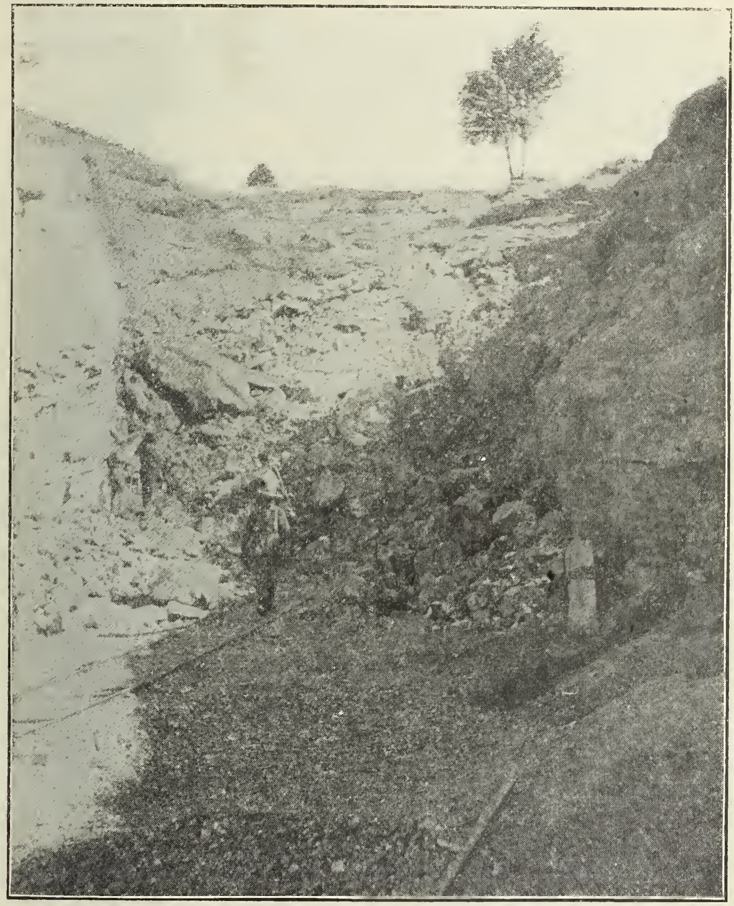
The discovery of copper pyrites in the Coe iron mine near Eldorado station in Hastings county was referred to in the last Report of the Bureau. As soon as discovered the mine was leased under option to the Medina Gold Mining Company, Col. Saunders, president, who were under contract to sink 50 feet on the vein. Work has steadily progressed and the shaft is now down about 50 feet. A crosscut was run at a depth of about 30 feet, showing a good width of vein.

The copper pyrites when first discovered occurred in a vein a few inches in width in the hematite. This vein widened as sinking progressed, developing a lead of considerable width. Copper stain had previously been noticed when the mine was worked for the iron, and a small piece of native copper was found near the surface of the deposit. The ore is high grade, due no doubt to a secondary enrichment from the leaching out of the copper from the overlying gossan.

The Parry Sound Copper Mining Company did a little work at the Wilcox mine during 1904. The work consisted of deepening shaft No. 1 from 135 feet to 145 feet, and then crosscutting 100 feet. The ore averages about 4 per cent. copper.

FELDSPAR MINES

The production of feldspar in Ontario has up to the present been confined exculsively to Frontenac county. Owing to the somewhat limited demand for the mineral, and consequently the difficulty in finding a market, no very large production is likely to be reached. During 1904 work was done on several properties along the Kingston and Pembroke Railway in Bedford, Oso and Portland townships.



No. 2 pit, or northeast part of the Richardson feldspar mine.

The largest producer is the mine owned and operated by the Kingston Feldspar Mining Company in Bedford township, known as the Richardson mine. This mine has been a steady producer since 1900, the spar maintaining its high grade qualities which earned for it its market. An analysis shows it to contain the following:

	Per Cent.
Silica	66.23
Alumina	18.77
Potash	12.09
Soda	3.11

The feldspar is mined from a large open cut and is hoisted to the top of the hill, a distance of 50 feet, in 2-ton buckets. These loaded buckets are conveyed on wagons to pontoons on Thirteen Island lake, on which the ore is loaded. It is then

taken by tug across the lake to a portage, placed on cars and drawn across to Thirty Island lake. From there it is taken by tug and pontoon to a spur of the Kingston and Pembroke Railway at Glendower, where by means of a steam hoist the ore is loaded directly on to the cars, or into a pocket. The company have been at a large expense to complete this system of transportation. Now the spar is not handled by manual labor from the time it is mined until it is delivered on the boats at Kingston.

The quarry is divided into two openings, No. 1 or southwest pit, and No. 2 or northeast pit.

No. 1 is at a depth of 50 feet and has an area of 250 feet long by 50 feet wide. No. 2 is the same depth and is 300 feet long by 30 feet wide.

A ditch was dug in the spring of 1905, 600 feet long and 15 feet deep to drain the pit. Stoping is being carried on from the north end of No. 2 pit, which has a width

Loading skips on pontoons at Thirteen Island lake, Richardson feldspar mine.

of 35 feet by the same depth, and on the south side of No. 1 pit, where a stope 15 feet in height is being begun. By means of two derricks hoisting is being done from both pits by two duplex cylinder hoists. An output of 100 tons per day is now maintained.

A force of thirty men is employed under superintendent M. J. Flynn.

The two pits or open cuts, while coming together on the eastern side, are separated on the western side by a large mass of quartz which intrudes into the feldspar. A very perfect separation of the quartz and feldspar is here seen, the quartz having crystallized out in large masses and overlying the feldspar on the western side of No. 2 pit.

Another mine a short distance from the Richardson on the south half of lot 3 in the third concession of Bedford, owned by Charles Jenkins of Petrolia, was worked

for about six months during the year. A small force of men was employed under foreman Jos Harris. Three pits were being worked at the time of inspection with a production of 25 to 30 tons per day.

Mr. A. M. Chisholm worked a property on lot 5 in the fourth concession of Bedford for a short time during the year. About 300 tons of feldspar were mined during this period.

On lot 10 in the fifth concession of the township of Oso, near Sharbot lake, Messrs. Mills & Cunningham of Kingston did some development work. Considerable stripping was done, and a very good body of ore exposed.

MICA MINES

The mica production in Ontario in 1904 was a great deal less than during the preceding year. This decrease was due to the depression in the electrical business in the United States and consequently a lessened demand for the phlogopite (amber mica). The mica mines of Ontario are becoming every year more under the control of the large electrical companies, who mine simply for their own use and not for the market. On this account, there is a smaller demand for mica on the market, and the production varies with the consumption.

As a result of this policy the General Electric Company, who are the largest producers in Ontario, only operated one of their mines during the last year. Their other mining work consisted wholly of prospecting for new deposits. The Hanlan mine near Perth, which produced a large tonnage in 1903, remained idle during 1904, and the Lacey, probably the largest producer in Canada, was not worked to its full capacity.

Another thing which has without a doubt affected the mica industry is the turning of old dumps, which were thrown out at a time when the grades of mica below five inches square were not marketable. This has furnished a large quantity of very cheap mica of the small sizes. This is more particularly applicable to India and the United States in the white mica trade than to Canada. These dumps have now nearly all been worked over, and as a result the price of mica will almost necessarily increase. Very little new development has taken place lately in the mica trade.

The utilization of the so-called "milky" mica has become a question of interest to some of the companies. This "milky" mica is a steel gray color, while the typical phlogopite is brown to amber. While the physical conditions of these two micas are so different, their optical properties are similar, with the exception of microscopic inclusions symmetrically arranged in the "milky" variety. This "milky" mica can be used, but the cost of cleaning and splitting is greatly increased and the percentage of marketable mica resulting therefrom very small. As pointed out by the writer in a paper read before the Canadian Mining Institute, the change is due to a segregation of titanium by secondary alteration.

A comparison of the analysis of the three varieties of mica is here given:

	Muscovite.	Phlogopite.	Biotite.
SiO_2	45.2	39.66	39.5
Al_2O_3	33.5	17.00	16.5
Fe_2O_3	2.7	0.27	5.
FeO	1.2	0.20	12.
MgO	1.	26.49	12.5
BaO	..	0.62	..
Na_2O	1.	0.60	0.7
K_2O	9.5	9.97	8.8
TiO_2	..	0.56	1.
F	0.5	2.24	1.
H_2O	4.5	2.99	2.8

Muscovite (white mica) has not been produced commercially in Ontario, although it is known to occur in several localities. Deposits have been found in the township of Methuen, Peterborough county, occurring in syenite dykes associated with corundum. This mica is, however, as a rule too hard for electrical purposes, and the deposits have not as yet been developed to any extent. A deposit of muscovite has been found near Mazinaw lake, Effingham township, county of Lennox. This deposit is in a pegmatite dike which has been traced for a couple of miles from surface outcroppings. Some of the mica is a very clear muscovite, but parts of the dike contain mica quite badly stained and spotted with iron.

General Electric Company

This company during the year 1904 operated the Lacey mine in Loughboro' township, and during the summer months carried on considerable prospecting work in other parts of the township, and also near Perth in the township of Burgess.

The Lacey mine has for the last few years ranked as the largest producer of mica in Ontario, and has probably produced the largest quantity of mica of any mine in Canada. The mine was opened about the year 1899 by J. W. Trousdale of Sydenham, who worked it under lease until the first of the year 1901, when it reverted to the owners, The General Electric Company of Schenectady, N. Y., who have since operated it with Mr. G. W. McNaughton, manager.

Lacey mica mine, Frontenac county, owned by General Electric Company.

The main shaft has now a depth of 185 feet (an increase of 50 feet since last inspection), having a dimension at the bottom of 15 feet by 18 feet.

The first level is at a depth of 60 feet. From this level in the southeast drift at 100 feet from the shaft a winze has been sunk to the third level, and a little stoping done.

The second level at a depth of 85 feet has a drift running northwest 45 feet. A crosscut is being driven in the hanging wall from the second level platform to cut a parallel vein of mica located by the diamond drill. A distance of 31 feet had been driven at the time of inspection. Since the inspection of the mine a large deposit of mica has been located by this crosscut northeast of the old ore body.

The third level at a depth of 95 feet has a drift southeast 130 feet, being an increase of 88 feet. The floor of the easterly drift from the main drift has been broken through to the level below.

The fourth level at a depth of 117 feet has two drifts running southeast of the shaft, the easterly one being 135 feet and the westerly 130 feet in length.

The fifth level (new) is at a depth of 140 feet with northwest drift 60 feet in length. Two drifts have also been run on this level southeast of the shaft. The easterly drift has a length of 135 feet and westerly 130 feet. The floor between the fourth and fifth levels in the easterly drift has been stoped out.

The sixth level at a depth of 165 feet has a southeast drift 60 feet and a northwest drift 40 feet in length.

Northwest of the shaft the mica has all been stoped out from the second to the fifth level. Timbers have been placed under the roof overhanging this stope, and pillars left between the stope and shaft. Stulls have been placed in the floor of the fourth level, which has been broken through, to thoroughly protect the lower workings.

The surface machinery consists of a class B Rand air-compressor, which furnishes 1,015 cubic feet of fresh air per minute at normal capacity; two Jenckes boilers of 70-h. p. capacity each, with feed water heater and pumps. A hose house has been built and small pump placed therein to pump water from the old Lacey pit for the compressor and for fire protection. The company also own a diamond drill, and some 2,000 feet of drilling has been done at the Lacey mine prospecting for new ore bodies and determining the extent of the old ones.

The General Electric Company carried on prospecting during the past year on the Canada Company's lot at Mud lake, Loughboro township, and on the Burns property, lot 11 and east half of 12 in the seventh concession, township of North Burgess. This lot adjoins the lot on which the Hanlan mine is situated.

Freeman Mica Mine

Richardson Bros. of Kingston worked all year on the Freeman property on lot 7 in the ninth concession of Loughboro township. There are three parallel veins. The mica in the middle vein is milky and badly twisted. A very fair quality is found in the parallel veins. A shaft 80 feet deep has been sunk and the vein stoped out for 40 feet. The mica was all cleaned at the mine. It is the intention of the management to begin work on the vein of black mica on the west side of the lake, as the demand for this quality is increasing.

Baby Mine

The Baby mine, about 14 miles from Perth, on lot 11 in the fifth concession of North Burgess township, was re-opened during the year. The mine was worked some years ago as a large open pit 15 to 20 feet across and 165 feet deep. A mining camp has been built and boiler and hoist installed.

The west half of lot 6 in the ninth concession of North Burgess was worked under lease by Messrs. Montgomery and Adams of Perth. A shaft 40 feet deep was sunk on the vein having a width of 6 feet. A short drift was run at the bottom of the shaft northwest along the vein. The mica is cleaned at the Adams trimming works at Perth.

Kent Bros

The operations of this firm are largely confined at the present time to their mine near Buckingham, Quebec. The Bob's lake mine in Bedford township was, however, worked until October of 1904, when it was temporarily closed. The mica produced from this mine was cleaned at the firm's mica works at the foot of Princess St., Kingston. The mica from their mine in Quebec is also sent here to be cleaned. There are seven men employed in thumb-trimming and twenty-two girls in thin-splitting the mica.

Messrs. Mills & Cunningham of Kingston worked an amber mica property on the north part of lot 9 in the second concession of South Sherbrooke township, county of Lanark, for some months during the year. The mica was found in a vein of calcite, which was considerably broken by faults and had been subjected to much pressure.

Prospecting was also done on lots 4 and 7 in the third concession, and lot 2 in the fourth concession of South Sherbrooke.

Mica Trimmimg Works at Ottawa

The General Electric Company have large works on the corner of Isabella and Elgin streets, Ottawa, which are fitted up with cutting knives, thin-splitting tables, and all appliances necessary for the production of mica in its marketable state. The mica from all the company's mines is shipped here for preparation. After preparation the mica is sent to the company's works at Schenectady, N.Y. A force of ninety, of whom fifty girls are engaged in thin-splitting, is employed under superintendent R. E. Nivison.

The Laurentide Mica Company have recently opened a large factory on the corner of Queen and Bridge streets. This company ship all their mica to the Westinghouse Company at Pittsburgh, Pa., for use in the manufacture of electrical machinery. Some of the mica is obtained from this company's own mine at Chelsea, Quebec, and the rest from independent producers in both Ontario and Quebec. A force of 175 girls is engaged in thin-splitting the mica, twenty-four on the knives, and ten thumb-trimming, under superintendent Chas. Girteau.

Eugene Munsell and Company have steadily employed an average of about twenty, nearly all girls, engaged in thin-splitting, under superintendent S. O. Fillion. Most of this mica is bought from the small producers of Ontario and Quebec.

PHOSPHATE OF LIME

The phosphate industry, which has been dormant in eastern Ontario for some years, received some attention from German chemists in 1904. A large number of phosphate properties were purchased and a company formed known as the Dominion Improvement and Development Company, with head office at Hamburg, and branch office in New York. Work was done last season on lot 13 in the sixth concession of North Burgess. A shaft 20 feet square was sunk and a quantity of mixed phosphate and rock taken out Camp buildings were put up and preparation made for the production of a larger tonnage of ore.

GRAPHITE

The Black Diamond graphite mine was leased from the Ontario Graphite Company, Limited, by Mr. Rinaldo McConnell of Ottawa, and has been operated by him since 1st May, 1904. Under Mr. McConnell's management a dam was built to enable the old workings to be unwatered, which owing to a cave-in, had bee filled by water

from the lake. The mine was then pumped out, but the workings were found to be in such a dangerous condition that they were abandoned, and a new shaft begun 100 feet southwest of the old shaft and running parallel with the old workings. The shaft is sunk on an incline of thirty degrees, following the dip of the vein, and has a depth of 170 feet. Some ore has been stoped from the south side of the shaft.

The shaft is fitted with skip-track and ore is hoisted by skip driven by duplex cylinder single drum hoist operated by compressed air. The skip-track and the way for the men to enter the mine was in the same shaft and not separated by partition as required by the Mines Act.

The new power plant on the Madawaska river, two miles from the mine, has been completed, furnishing power to run compressor and mill.

The mill was closed at the time of inspection in March 1905, as the management was installing a new system of air separation. A force of thirty men was employed under superintendent Allan McDonell.

A new stamp is being successfully used, which greatly increases the output. This is conical in form, fitting in a mortar of the same shape.

The McConnell graphite mine in North Elmsley township, county of Lanark, about seven miles north of Perth, which was closed in 1903, has recently been opened, and work is expected to be carried on the coming summer in both mine and mill.

ACTINOLITE AND ASBESTOS

The operations of Mr. Joseph James and the International Asbestos Company in the grinding of actinolite and production of short fibre asbestos was brought to a standstill last June by the blowing out of their mill dam by a lumber company. As a consequence, all operations in that line have ceased, pending a suit regarding the utilization of the water power.

This industry, which is one of the oldest mining industries in continuous operation in the Province, has recently received attention from operators both in England and the United States. It is to be hoped that the difficulty now hampering the business will soon be removed.

TALC

The Henderson talc mine on lot 14 in the fourteenth concession of the township of Huntingdon, was operated for two months during 1904 by Mr. S. Wellington of Madoc, who had the property under lease. A shaft had previously been sunk to a depth of 53 feet and short drifts run in both directions along the deposit at a depth of 35 feet, as well as some crosscutting done, proving it to have a width of 20 feet. During the time of operation in the past summer no new development work was done.

A quantity of talc was mined from the drifts by both underhand and overhand stoping. The best grade product was shipped to Newark, N. J.

CALCIUM CARBIDE

With the increased use of acetylene gas for lighting purposes in small towns and villages, which are not supplied with electric light and gas plants, the manufacture of calcium carbide has been placed on a firm basis, and a steady demand is assured.

The Ottawa Carbide Company, with works at Ottawa, have a total of twenty furnaces. At the time of the writer's visit only five to eight furnaces were in operation, owing to the low water supply. The process for the formation of carbide consists of the fusion of lime and coke in an electric furnace according to the reaction, $CaO + 3\ C = CaC2 + CO$. The fusion requires a current of 1,500 amperes and a voltage of 75. This must be kept constant, which is accomplished by raising or lower-

ing the upper electrode. The lower electrode is a block of carbon let into an iron base plate, while the upper electrode is a suspended carbon block.

After fusion the furnace is dumped and the unfused part returned to the furnace. On being cooled, the scale is taken off the fused mass by means of pneumatic hammers or chisels. The carbide is then crushed to a uniform size and packed in tins containing 100 pounds. The limestone used in the production of the lime (CaO) is from Welland county. It is very pure, low in magnesia and belongs to the Corniferous formation. It is quarried at Port Colborne and Skerkston, and is also burnt there by natural gas as fuel. An analysis shows the following percentage:

Silica	2.00
Alumina and ferric oxide	1.10
Lime	51.00
Magnesia	1.10
Phosphorus	.015
Sulphur	.05

The company at Ottawa produce their own electric power.

The calcium carbide factory at Merritton, Welland county, was also in operation during the year.

PETROLEUM AND NATURAL GAS

BY E T CORKILL

The past and present year have seen renewed activity in the petroleum fields of southwestern Ontario. This activity is due to the finding of two new oil fields, namely, the Moore township field in Lambton county, and the Leamington field in Mersea township, county of Essex. The first well in the Moore township field was brought in in July 1904, on lot 3 in the tenth concession, and in the Leamington field on 1st June 1902, on the farm of Gustavus Straubel, lot 238, Talbot Road.

In March 1905, under instructions from Mr. T. W. Gibson, Director of the Bureau of Mines, the writer paid a visit to nearly all the oil and gas producing fields of southwestern Ontario, for the purpose of procuring as full and authentic information as possible regarding the new oil and gas fields that were being opened up, as well as of ascertaining any new developments that were being made in the older fields.

Two very complete reports dealing with the southwestern peninsula have been published by the Geological Survey of Canada. The first was The Geology of Canada (1863) in which are summed up the results of the observations on the geology of the region made by Logan, Hunt and other investigators. In the Report of the Geological Survey of 1890-91, Mr. H. P. H. Brummell takes up the occurrence of petroleum and natural gas in Ontario, giving logs of a great number of wells and also sections illustrating the sequence of the Palaeozoic formations in Ontario.

Individual fields have been described in recent reports of the Bureau of Mines. In the Thirteenth Report, Part II, the chief geological divisions and outcropping rocks are shown. In Vols. III and VI of the Journal of the Canadian Mining Institute, Mr. Eugene Coste has published papers on Natural Gas in Ontario.

PETROLEUM FIELDS

The production of petroleum in Ontario has so far been largely confined to the county of Lambton. The first oil was found in this country about the year 1862, a few years after the great oil strikes in the United States. There have been in the county of Lambton alone about eleven thousand producing wells, some of which have been yielding oil for over forty years. At the present time there are 8,100 wells in operation at Petrolea, and 1,000 at Oil Springs. Probably the most remarkable thing about this field is its permanency of flow and the small average yield per well. One group of 100 wells the writer visited, produced 150 barrels a month, all the wells being operated from a central pumping station.

Petroleum has for some years been known to occur on Manitoulin Island, in fact it is recorded that the first oil found in Canada was that discovered on this island. A company was formed in 1865 to bore for oil, but the venture apparently was not successful. At the present time more drilling is being done there, with prospects of better results.

Oil has also been found in other counties in southwestern Ontario.

About seven years ago petroleum was struck in the township of Dutton, Elgin county. The field here is small, comprising about 400 acres, but the wells are shallow and have a steady production. The oil is obtained from the Corniferous at a depth of 440 feet.

In Kent county small fields have been located in different parts. In Raleigh township on lot 18, in the twelfth concession, a flowing well was struck in November of 1902, known as the "Gurd gusher." Very few wells however were productive in this field. The "Gurd" well has ceased to flow, and pumping operations have been given up in the field. The Wheatley field in the township of Romney has a steady production, though a small average yield per well.

The Bothwell field in Zone township, county of Kent, has between 200 and 300 producing wells. This field is considered a good paying proposition. It has a small production per well, but the output last year, according to Mr. Kennedy, secretary of the United Oil and Gas Company, did not depreciate two per cent., as compared with the previous twelvemonth. The wells are quite shallow, averaging in depth about 600 feet, and formations drilled through are very similar to those in the Petrolea field.

North of the Bothwell field in Euphemia township is another group of wells with a small production. The wells, however, are very shallow, averaging 370 feet (the thickness of drift being 53 feet).

Essex county, which for some years was a large producer of natural gas, bids fair now, like the Petrolea field, to become an important producer of petroleum.

Oil had not been found in commercial quantities in Ontario, until a very few years ago, in any formation but the Corniferous, and oil men had almost become convinced that drilling to greater depths was useless. In the spring of 1902 a company was formed in the town of Leamington to explore for gas and oil in that section. A well was sunk on lot 238, Talbot road, and oil was struck at a depth of 1,074 feet on 1st June 1902, in a formation previously not recognized as a prolific oil stratum, namely the Guelph formation. This formation is a very porous dolomitic limestone, and has been known for years as a producer of natural gas in this county. No very large oil producers, however, were found until 1905. This year has witnessed the bringing in, in this field, of some large flowing wells, the largest reported as yet being the Hickey No. 4, which started off with a flow of 1,200 barrels per day; this it maintained for nearly three days, and then gradually diminished day by day until it is now down to about 200 barrels a day, but still flowing. On 10th April a gusher was truck on lot 9, concession 4, Mersea township, on the farm of Patrick Smith. This is also stated to be a very large producer. The exceeding porosity of the productive sand in this field points to a good prospect for a producing oil field, if the oil is not too near the salt water. At present the oil sent to the refinery at Sarnia contains considerable water. In one month in the early part of 1905, 3,000 barrels of oil were shipped from this field to the refinery.

Another new field was found in 1902-03, the productive area being a still lower horizon in the geological scale than the formation in which the oil is found in the Leamington field. This field is situated in the county of Brant, near the city of Brantford, having its productive area in the Medina. Several oil wells have been brought in, with small production. Gas is also found along with the oil in most of the wells. A well has just been drilled to the Trenton in this field, the log of which is given in another part of this report.

NATURAL GAS FIELDS

The production of natural gas in Ontario is now limited almost entirely to the counties of Haldimand and Welland. The Essex field, which was so prolific a source of gas some years ago, has almost entirely ceased to produce, hardly sufficient gas

being obtained to supply the towns in proximity to the old fields. In October 1901, the exportation of gas to Detroit was stopped by the Ontario Government by Order-in-Council revoking the license of occupation which authorized the exporting company to use the bed of the Detroit river for the purposes of its pipe line, in the hope that by so doing the life of the field would be prolonged. This, however, did not have the desired effect, and the field is now practically abandoned. Seven gas wells were drilled north of this field in 1904, three or four of which are producing from 3,000 to 90,000 feet per day. These wells are situated practically in the oil field A rock pressure of 398 lb. was recorded. The gas is used to supply the town of Leamington, and also for drilling and pumping in the oil field.

The first well in the Welland field was struck in August 1889, on lot 35 of the third concession from lake Erie, in Bertie township, seven miles east of Port Colborne. This well was drilled by the Provincial Natural Gas and Fuel Company of Ontario, Limited. The gas was struck in a white sandstone of the Medina formation at 836 feet. Previous to this, however, a few wells had been sunk at Port Colborne and vicinity, the first well being put down in August of 1886. These wells were small producers, 70,000 feet per day being the largest flow obtained.

From fourteen wells put down by the Provincial Natural Gas and Fuel Company a supply of 30,895,000 cubic feet of gas per day was obtained. This company has supplied Buffalo since January 1891, and during the past year has constructed 8-inch high pressure pipe lines to Niagara and Chippewa, the former twelve miles in length, and the latter one and one-half miles. Gas is also delivered at Bridgeburg, Fort Erie, Sherkston, Stevensville, Crystal Beach and other points along the lake shore, and to any farmer applying for it along any of their lines.

The Winger field, in Wainfleet township, was opened in 1903, and has now eight producing wells which have a rock pressure of 260 lb. Another field opened by the same company during 1904 is in the centre of the township of Crowland. In this field the gas is found in the Clinton formation.

The Mutual Natural Gas Company, Limited, of Port Colborne, controls a field near that town, with an area two miles east, six miles north and three miles west. The northern part of this is new territory opened up only two years ago, and is the most productive. The gas is here found in the Clinton. The company has 35 producing wells and supplies the towns of Port Colborne, Humberstone and Welland. Just west of the Mutual Company's properties the Welland County Lime Works Company utilizes the gas in the burning of lime from wells it has just put down.

Northwest of Dunnville in the township of Canborough, Haldimand county, the Dominion Natural Gas Company has put down 34 wells in what is known as the Attercliffe field, and five wells outside of this field. The wells produce from 25,000 to 75,000 cubic feet per well. An 8-inch high pressure pipe line has been constructed to Hamilton and Dundas from this field. A pressure of 60 lb. is attained at Dundas. The Citizens' Natural Gas Company have nine producing wells in Attercliffe field and supply gas to consumers in the town of Dunnville.

ORIGIN OF OIL AND GAS

In dealing with the origin of petroleum and natural gas the aim of the writer is solely to treat the subject from the literature of the subject by giving extracts from those writings in which the chief theories have been advanced or supported.

Theories of Inorganic Origin

Two of the first writers to advocate the theory of inorganic origin were M. Berthelot and M. Mendeljeff. A paper was published by M. Berthelot in 1866, wherein he says:

"If in accordance with an hypothesis recently announced by M. Daubre, it is to be admitted that the terrestrial mass contains free alkali metals in its interior, this hypothesis alone, together with experiments that I have lately published, furnishes

almost of necessity a method of explaining the formation of carbides of hydrogen. According to my experiments, when carbonic acid, which everywhere infiltrates the terrestrial crust, comes in contact with the alkali metals at a high temperature, acetylides are formed. These same acetylides also result from contact of the earthy carbonates with the alkali metals even below a dull-red heat.

"Now the alkaline acetylides thus produced could be subjected to the action of vapor of water; free acetylene would result if the products were removed immediately from the influence of heat and of hydrogen (produced at the same time by the reaction of water upon the free metals) and the other bodies which are found present. But in consequence of the different conditions the actylene would not exist, as has been proved by my recent experiments. In its place we obtain either the products of its condensation, which approach the bitumens and tars, or the products of the reaction of hydrogen upon those bodies already condensed, that is to say, more hydrogenated carbides. For example, hydrogen reacting upon the acetylene engenders ethylene and hydride of ethylene. A new reaction of the hydrogen either upon the polymeres of acetylene or upon those of ethylene would engender formenic carbides, the same as those which constitute American petroleum. An almost unlimited diversity in the reaction is here possible, according to the temperature and the bodies present."

In 1877 M. Mendeljeff published a paper setting forth his theories on the Inorganic Origin of Petroleum and Natural Gas. From a resumè of his paper the following is an extract:—

"Admitting the existence of metallic carbides, it is easy to find an explanation not only for the origin of petroleum, but also for the manner of its appearance in the places where the terrestrial strata, at the time of their elevation into mountain chains, ought to be filled with crevices to their centre. These crevices have admitted water to these metallic carbides. The action of water upon the metallic carbides at an elevated temperature and under a high pressure, has generated metallic oxides and saturated hydrocarbons, which being transported by aqueous vapor, have reached those strata where they would easily condense and impregnate beds of sandstone, which have the property of imbibing great quantities of mineral oil."

Also in Mendeljeff's "Principles of Chemistry," vol. I, page 364:

"As during the process of the dry distillation of wood, seaweed and similar vegetable debris, and also when fats are decomposed by the action of heat (in closed vessels) hydrocarbons similar to naphtha are formed, it was natural that this should have been turned to account to explain the formation of the latter. But the hypothesis of the formation of naphtha from vegetable inevitably assumes coal to be the chief element of decomposition, and naphtha is met with in Pennsylvania and Canada, in the Silurian and Devonian strata, which do not contain coal, and correspond to an epoch not abounding in organic matter. If we ascribe the derivation of naphtha to the decomposition of fat (adipose animal fat) we encounter three almost insuperable difficulties: (1) Animal remains would furnish a great deal of nitrogenous matter, whilst there is but very little in naphtha; (2) the enormous amount of naphtha already discovered as compared with the insignificant amount of fat in the animal carcase: (3) the source of naphtha always running parallel to mountain chains is completely inexplicable."

"Another fundamental reason is the consideration of the mean density of the earth. Cavendish, Airy, Cornu, and many others who investigated the subject by various methods, found that, taking water as 1, the mean density of the arth is nearly 5.5. As at the surface water and all rocks (sand, clay, limestone, granite, etc.) have a density less than 3, it is evident (as solids are but slightly compressible even under the greatest pressure) that inside the earth there are substances of a greater density, namely, not less than 7 or 8. . . . . . For this reason it is possible that the interior of the earth contains iron in a metallic state."

Many other eminent chemists and geologists have made investigations and have written in support of the Inorganic theory. Mr. Eugene Coste, in the Journal of the Canadian Mining Institute, Vols III and VI, has published two papers dealing more particularly with the occurrences in Ontario, and the evidence here furnished in support of this theory. Mr. Coste points out the following:—

"1st. In the Archean rocks we find carbon under the form of graphite in gneisses (1) in pegmatite dikes, in granites, (2) gabbros, (3) and other rocks, the igneous origin of which is undeniable.

"2nd. In the crystals of igneous gneisses and of most granites and other eruptive rocks, gaseous and liquid inclusions are most abundantly found, and these are very

often constituted by carbonic acid and hydrocarbons, and also often contain chloride of sodium in solution or in minute crystals.

"3rd. Petroleum, or semi-liquid or solid bitumens have often been noticed and cited by many observers as occurring in traps, basalts, or other igneous rocks, as for instance by Sir William Logan[1] in a green stone dike at Tar Point, Gaspé, Province of Quebec: by Mr. Rateau in trachytes in Galicia, and by Professor Arthur Lakes[2] in injected volcanic dikes in Archelutu county, Colorado.

"4th. Volcanic rocks forming vertical necks and pipes across horizontal strata. and containing carbon in the pure form of diamonds, are also well known to constitute in South Africa the deposits of these precious stones. These diamentiferous volcanic necks and pipes also contain large cavities filled with gaseous hydrocarbons as pointed out by Mr. Moulle.

"5th. We now come to the hydrocarbon and carbonic acid in volcanic manifestations of to-day. Not later than a few months ago the civilized world was suddenly startled and horrified at the report that an explosion of Mount Pelee had wiped away in a few minutes the entire population of St. Pierre, Martinique Island. From the account of the catastrophe then published, it is quite certain that a fearful blast or tornado of gases suddenly shot from the side of the volcano, asphyxiating and burning in a moment 30,000 people. Nothing else, we submit, but gas could carry death so suddenly to so many thousand people, inside and outside their houses over a whole city."

To quote further from Mr.Coste:[3]

"It is indeed quite clear that one believing in the organic theory of the origin of natural gas and petroleum would naturally consider that there might be natural gas or petroleum deposits under any part of the peninsula of southwestern Ontario between the Georgian bay, lake Huron and lake St. Clair to the northwest and lake Erie and lake Ontario to the southeast, as the whole of that large section of the country is underlaid with Devonian and Silurian strata more or less fossiliferous; and it would be and has been impossible to any one following that organic origin theory to localize any particular district of that peninsula where these hydrocarbon products should be found by drilling. In fact, according to that theory, if found in one place, these products should be found in almost any other part of the peninsula. On the other hand, for one accepting, as I did, the volcanic origin of these products as gaseous emanations from the interior of the earth along certain fissured and fractured zones of the crust of the earth, it was possible to select in southwestern Ontario several likely new gas fields by mapping out the probable continuation in Canada of these fissured and fractured zones from other gas and oil fields already located and developed on the same zones in the United States."

Theories of Organic Origin

The organic theory of the origin of natural gas and petroleum is supported by those who believe that these substances are derived from vegetable and animal matter contained in the rocks in which they are found or in associated strata. Compounds similar to, or identical with, petroleum and natural gas, are derived by the process of destructive distillation from both vegetable and animal substances. The manufacture of artificial gas from bituminous coal is also a familiar illustration of the possibilities in this direction. Bituminous shale may be substituted for coal in the manufacture, and may be made to yield a series of these bituminous products, including both petroleum and gas.

Beyond the fact that petroleum and natural gas are derived from animal and vegetable remains, there is little agreement among the most responsible authorities as to their particular mode of origin. Two views, however, have become especially prominent. These are that hydrocarbons were formed by (1) the primary distillation of vegetable or animal remains, and (2) a second distillation or decomposition of organic remains at some period subsequent to their deposition.

Dr. E. Orton thus defines these different opinions:[4]

"The first view is that petroleum is in large part derived from the primary decomposition of organic matter that was stored in or associated with, the strata that now

1 Geology of Canada, 1863, pp. 402 and 789. 2 Min. Resources of the U. S., 1901, p. 561
3 Journal Can. Min. Inst., Vol. III. p. 79. 4 Geol. Survey of Ohio, Vol. VI.

contain it. According to this view the decomposition was mainly effected *in situ*, and the product resulting is, therefore, mainly indigenous to the rock in which it is found. The last feature is seized upon in most popular statements, and a theory of indigenous origin is made to include most beliefs of this class. It must be borne in mind, however, that no author is to be found who holds strictly and consistently to such indigenous origin, but the name can still be used as a general designation without harm.

"The second view is, that petroleum is derived from the secondary decomposition of organic matter stored in the rocks. It supposes the original vegetable and animal matter to have suffered a partial transformation and to be now held in the rocks as a hydrogen compound, from which, by a process of distillation, oil and gas are derived. The so-called bituminous shales are counted the chief sources of these products. After distillation it is held that the gas and oil are mainly carried upward by hydrostatic pressure to some overlying porous stratum that serves as a reservoir. This class can be conveniently grouped under the name of the distillation theory."

The Primary Decomposition Theory

The greatest exponent of the theory that petroleum is derived from the primary decomposition of organic tissues is Dr. T. Sterry Hunt. He urges that petroleum mainly originates in and is obtained from limestones. When found in limestones he counts the oil indigenous, but when found elsewhere as in sandstones and conglomerate, he counts it adventitious and he then refers it to underlying limestones. In speaking of the oil fields of Canada he says:[5]

"The facts observed in this locality appear to show that the petroleum of the substance which has given rise to it was deposited in the bed in which it is now found at the formation of the rock. We may suppose in these oil bearing beds an accumulation of organic matters, whose decomposition in the midst of a marine calcareous deposit, has resulted in their complete transformation into petroleum, which has found a lodgment in the cavities of the shells and corals immediately near. Its absence from the unfilled cells of corals in the adjacent and interstratified beds forbids the idea of the introduction of the oil into these strata either by distillation or by infiltration. The same observations apply to the Trenton limestone, and if it shall be hereafter shown that the source of petroleum (as distinguished from asphalt) in other regions is to be found in marine fossiliferous limestone, a step will have been made toward a knowledge of the chemical conditions necessary to its formation."

He also says:[6]

"In opposition to the generally received view which supposes the oil to originate from a slow destructive distillation of the black pyroschists, belonging to the middle and upper Devonian, I have maintained that it exists, ready found, in the limestones below."

Again:[7]

"It has already been shown that the petroleum of Canada occurs in two distinct horizons; the one in the limestones of the Trenton group, and the other in those of the Corniferous formation. To this it must now be added, that the petroleum of Gaspé probably belongs to an intermediate position, and it to be referred to limestones of Upper Silurian age."

Also in writing of a dolomite in the Niagara formation met with near Chicago, Illinois, he says:

"A layer of this oleiferous dolomite, one mile square and one foot thick will contain 1,184,832 cubic feet of petroleum, equal to 8,850,069 gallons of 231 cubic inches and to 221,247 barrels of forty gallons each. Taking the minimum thickness of 35 feet assigned by Mr. Worthen to the oil-bearing rock at Chicago, we have in each square mile of it 7,743,745 barrels of petroleum. . . . . . With such sources ready formed in the earth's crust, it seems to me, to say the least, unphilosophical to search elsewhere for the origin of petroleum, and to suppose it to be derived by some unexplained process from rocks which are destitute of this substance."

Another important paper on petroleum formation is Wall's report on the Trinidad asphalt. He says:[8]

5 American Journal of Science, Vol. XXXV., p. 168. 6 American Journal of Science, Vol. XLVI., p. 361. 7 Geology of Canada 1863, page 786. 8 Quart. Journal Geol. Soc. XVI., p. 467.

"When *in situ* the asphalt is confined to particular strata which were originally shales containing a certain proportion of vegetable debris. The organic matter has undergone a special mineralization producing bituminous in place of ordinary anthraciferous substances. This operation is not attributable to heat nor to the nature of distillation, but is due to chemical reaction at the ordinary temperature and under the normal conditions of the climate."

Origin by Secondary Decomposition.

This theory is upheld by Messrs. J. S. Newberry and S. F. Peckham, both of whom advance somewhat different opinions, though acknowledging that petroleum and gas are the product of the secondary rather than of the primary decomposition of organic substances. The former contends that the distillation is continuous and at a low temperature, while the latter holds to the view that the distillation was effected by the heat that accompanied the elevation of the Appalachian Mountain System.

In his paper on the "Rock Oils of Ohio," Newberry says:[9]

"The precise process by which petroleum is evolved from the carbonaceous matter contained in the rocks which furnish it is not yet fully known, because we cannot in ordinary circumstances inspect it. We may fairly infer, however, that it is a distillation, though generally performed at a low temperature."

Again he says:[10]

"The origin of the two hydrocarbons is the same, and they are evolved simultaneously by the spontaneous distillation of carbonaceous rocks. Where the oil and gas producing rocks and those overlying them are solid and compact, decomposition of the organic matter they contain takes place very slowly and the escape of the reacting hydrocarbons is almost impossible. Where they are more or less shaken up, decomposition takes place more rapidly; reservoirs are opened to receive the oil and gas, and fissures are produced which serve for their escape to the surface."

Also in the same volume, page 158, he says:

"We have in the Huron shale a vast repository of solid hydro-carbonaceous matter which may be made to yield ten to twenty gallons of oil to the ton by artificial distillation. Like all other organic matter this is constantly undergoing spontaneous distillation, except where hermetically sealed deep under rock and water. This results in the formation of oil and gas, closely resembling those we make artificially from the same substance, the manufactured differing from the natural products only because we cannot imitate accurately the process of nature."

From the preceding extracts Newberry's theory may be summarized as follows:

Oil and gas are the result of a continuous and spontaneous distillation of the bituminous matter of certain shales, from which the greater part of the two hydrocarbons is obtained.

A few brief extracts will be sufficient to state the theory advanced by Peckham. He says:[11]

"Bitumens are not the product of the high temperatures and violent action of volcanoes, but of the slow and gentle changes at low temperature, due to metamorphic action upon strata buried at immense depths. . . The alteration, due to the combined action of heat, steam and pressure that involved the formations of the Appalachian system from Point Gaspé, in Canada, to Lookout Mountains in Tennessee, involving the Carboniferous and earlier strata, distorting and folding them, and converting the coal into anthracite, and the clays into crystalline schists, along their eastern border, could not have ceased to act westward along an arbitrary line, but must have gradually died out farther and farther from the surface. The great beds of shale and limestone containing fucoids, animal remains and even indigenous petroleum must have been invaded by this heat action to a greater or less degree."

Dr. Orton says:[12]

"The double origin of petroleum from both limestones and shales—and it is not necessary to exclude sandstones from the list of possible sources—deserves to be universally accepted. In confirmation of this double origin, it is coming to be recognized

9 Ohio Agricultural Report, 1859. 10 Geol. Surv. of Ohio, Vol. I., 1873, p. 192.

11 Census of the United States, Vol. X. 12 Geol. Survey of Ohio, Vol. VI., p. 71.

that the oil and gas derived from these two sources generally differ from each other in noticeable respects. The oil and gas derived from limestones contain larger proportions of sulphur and nitrogen than are found in the oil and gas of the shales."

Rock Pressure of Gas

In connection with the origin of petroleum and natural gas, pressure is a very important factor to be considered. Four theories have been advanced, which explain the pressure by:

(1) The pressure due to the expansive nature of the resulting gas from the decomposition or distillation of organic remains.

(2) The pressure due to the weight of the overlying rocks.

(3) Hydrostatic water pressure.

(4) Pressure due to gaseous emanations from below.

The last two are probably the most important, and the two which are chiefly upheld by geologists at the present time.

The second theory is upheld by those who claim that the weight of the overlying rocks exerts a pressure which is available for driving the accumulation of gas out of the rocks that contain them. This would only be possible were the rock in a crushed state, as otherwise no pressure would be exerted on the gas contained in the spaces between the grains.

The third theory claims that the cause of the flow of both petroleum and natural gas is due to the pressure of a column of water depending for its height on the depth of the strata in which these substances occur. Prof. Orton upheld this theory and explained it to be similar in principle to the flow of water from artesian wells. The amount of pressure would therefore depend on the height to which the water column is raised, in case continuous porosity of the stratum can be assured.

The fourth theory is upheld by those who believe in the inorganic origin of natural gas and petroleum. Mr. Coste writes:[13]

"In every field where gas is found in several strata, the highest pressure is always recorded in the lowest or deepest strata. For instance, in the Welland county field the rock pressure of the gas was 300 lb. in the Guelph dolomite; 400 lb. in the Clinton; 525 lb. in the Medina white sand; and 1,000 lb. in the Trenton limestone; these enormous pressures decreasing as the gas travels up from below by friction through the small fissures and the small pores of the 'sands,' we submit, cannot be explained any other way than by a volcanic source from below."

THE GEOLOGICAL SCALE OF ONTARIO

In the geological formations of Ontario the possible productive areas of petroleum and natural gas comprise the Palaeozoic rocks which consist of strata of Devonian, Silurian, Cambro-Silurian and Cambrian age. Overlying these is drift of glacial and recent deposits. The thickness here assigned to each is the comparative thickness of the strata of the Welland field to that of the Lambton field, taken from an average of the deep wells put down in those fields.

RECENT AND GLACIAL DRIFT.	Marls, clay	50—125 feet.
	Boulder clay	
DEVONIAN	Portage and Chemung	0—100 "
	Hamilton	0—350 "
	Corniferous	0—250 "
	Oriskany	0—25 "
SILURIAN	Lower Helderberg	300—1580 " (at Petrolea.)
	Onondaga	
	Guelph	290—435 feet.
	Niagara	
	Clinton	30—155 "
	Medina	950—300 "
CAMBRO-SILURIAN	Hudson River	730—350 "
	Utica	175—350 "
	Trenton	730—750 "
	Bird's Eye and Black River	
	Chazy	
	Calciferous	
	Potsdam	

13 Journal Can. Min. Inst., Vol. III., p. 83.

Trenton Formation

This formation is the lowest in the geological scale in which either gas or oil has been found in any quantity in Ontario. The outcrops of the Trenton and other formations in Palaeozoic groups in Ontario have been described in the Thirteenth Report of the Bureau of Mines, Part II. Sections of these formations are given in the 1863 Report of the Geology of Canada.

A section of the Trenton in the vicinity of Montreal is as follows:[14]

	Feet.
"Black bituminous nodular limestones in beds varying from two to four inches separated by layers of black bituminous shale of from one to two inches thick. The beds are highly fossiliferous	10
Gray bituminous granular limestone in beds of from three to eighteen inches at the bottom, passing into black nodular bituminous limestone at the top, interstratified with black bituminous shale in irregular layers of from one to three inches	10
Gray granular bituminous limestone of the same character as before in massive beds of from ten inches to two feet thick	10
Black and dark gray bituminous nodular limestone in beds varying from two to eight inches in thickness	150
Black bituminous compact limestone containing about ten per cent. of argillaceous matter	350
	530

In the southwestern part of Ontario drilling has reached the Trenton in Lambton, Essex, Brant, Welland and Elgin counties. A little gas and oil was struck in this formation in Essex county, and a high pressure of gas obtained in one well drilled in Welland county. Near where the Trenton outcrops on Manitoulin island, small quantities of oil have been found at depths of from 150 to 250 feet.

Utica Formation

This formation consists of dark brownish-black shales, very brittle, interstratified with occasional beds of compact brownish limestone. The shales yield bitumen by distillation. They overlie the Trenton and have a thickness varying from 175 to 350 feet. The upper boundary of the Utica is not always distinct, as the Hudson River shale that overlies it sometimes graduates into it in color and appearance.

A section of this formation in ascending order gives:[15]

	Feet.
"Black brittle bituminous shale	19
Black brittle bituminous shale with two bands of yellow-weathering limestone, black within, probably magnesian, and fit for hydraulic purposes	8
Black brittle bituminous shale	23
Black brittle bituminous shale, breaking into small fragments in consequence of an imperfect cleavage independent of the bedding	11
Black brittle bituminous shale with Graptolithus pristis	245
Gray hard sandstone, interstratified with bands of black shale	5
Black brittle bituminous shale, interstratified with beds of sandstone	7
	318

Hudson River Formation

This consists of greenish and bluish arenaceous shales interstratified with dark gray arenaceous shales and light gray sandstone. With them are associated some few beds of arenaceous conglomerate with calcareous pebbles. These beds vary from 730 feet in thickness in Welland county to 350 feet in Essex county.

Medina Formation

The gray sandstone of the Hudson River passes into the red sandstone and shales of the Medina. A section of the Medina in Welland county gives in ascending order:

	Feet.
Red shales	830
White sandstone	18
Blue shales	12
White sandstone	10
Red sandstone and shales	73

14 Geology of Canada, 1863, p. 137. 15 Geology of Canada, 1863, p. 198.

Gas has been found in three horizons in the Medina, namely: 1. In the upper part of the red Medina sandstone. 2. In the upper white Medina sandstone. 3. In the lower white Medina sandstone.

Clinton Formation

On the Niagara river the Clinton is limited to a few feet, but gradually augments in thickness to the northward. It consists chiefly of thin-bedded white and gray limestones. Gas in found in one horizon in the Clinton in Welland county, namely, about ten feet below its surface. Gas and oil have been found in this formation in small quantities in Ohio.

Niagara Formation

The Clinton formation is generally described as being overlaid by the blue shales of the Niagara. These shales, however, thin out and disappear to the northward, and the shales are therefore included in the Niagara.

A section of the Niagara seen in the cutting of the Welland canal near Thorold is as follows in ascending order:

	Feet.
Bluish black magnesian limestone	10
Gray, coarse-grained sub-crystalline limestone	10
Bluish black bituminous shale with thin bands of impure limestone	55
Bluish gray argillaceous limestone	8
Dark bluish bituminous limestone	8
Light and dark gray magnesian limestone in beds varying from six to ten feet in thickness	26
Bluish bituminous limestone holding many fossils, principally corals	7
	124

Guelph Formation

These strata consist of a magnesian limestone, massive or thin-bedded. It is very porous with small drusy cavities, and is rich in fossils, the Megalomus Canadensis being the characteristic one. The dolomites at the top are bluish in color succeeded by white, yellowish white and grayish white. Gas has for some years been derived from the upper beds of the Guelph dolomite in Essex county, but oil was not known to occur in any quantity in this formation until 1904, when it was struck near Leamington.

Onondaga and Lower Helderberg

At the base this formation consists of red shales occasionally marked by green bands and spots. This first division is overlaid by greenish shales and marls. These strata abound in small veins and nodules of gypsum and readily disintegrate when exposed to the air. The third division, which is the true gypsum-bearing portion, consists of gray or drab colored magnesian limestones with grayish and greenish shales including two ranges of interstratified masses of gypsum. The upper division is a limestone with columnar markings on the surface of the beds. In Canada the Onondaga formation belongs chiefly to the upper portion. This consists of dolomites and soft crumbling shales which are greenish and sometimes dark brown or bluish in color and are often dolomitic. The dolomites are mostly of a yellowish brown or drab color, and are in beds seldom exceeding a foot in thickness. Some beds of bluish dolomites are also met with.

The lower beds of this formation in Lambton county are made up of what we may call the Salina. In some sections this reaches a thickness of about 800 feet, composed largely of salt interbedded with dolomite, the salt having a total thickness of some 700 feet.

Oriskany Formation

The Oriskany sandstone is a band of white or yellowish rather coarse and sharp-grained, slightly calcareous sandstone, varying in thickness from an inch to thirty feet.

Corniferous Formation

This formation is composed largely of bituminous limestones holding a large amount of chert or hornstone. The lower portion consists of beds of a light gray limestone. The upper portion is a limestone of compact texture and varies in color from drab and light gray through different shades of blue to black. The Corniferous was until very recntly the only oil-bearing formation in southwestern Ontario. Oil has been found in one horizon in this formation in what is termed the "lower lime." This is at a depth of about 65 feet in the formation. The formation has a total thickness of about 200 feet.

Hamilton Formation

This formation in New York state is divided into, in ascending order:

(1) Marcellus shales, (2) Hamilton group, (3) Tully limestone, (4) Genesee slates.

(1) The Marcellus shale is a black or brown bituminous shale or pyroschist, often pyritiferous, and closely resembling the Utica formation. The lower portion contains thin layers of dark colored impure fossiliferous limestone. In the upper part the shales are destitute of organic remains and lighter in color, becoming olive-gray and passing into the succeeding formation.

(2) The Hamilton group consists of a series of olive-colored or bluish calcareo-arenaceous and argillaceous shales weathering to ash gray or brown.

This, according to Mr. Hall, consists in ascending order of:

	Feet.
Olive shales	80
Coarse grained shales with a hard calcareous stratum at the top	40
Bluish and grayish blue very fossiliferous shales with large numbers of atrypa, spirifera and strophomena	90
	210

(3) The Tully limestone is a blackish blue concretionary fossilferous stratum, which has a thickness of about twenty feet in the eastern part of New York, but thins out westward and disappears before reaching lake Erie.

(4) The Genesee slates consist of black bituminous shales, very similar to the Marcellus division.

"At Kingston's Mills in Warwick we have 396 feet of soft gray shales and soapstones of the Hamilton formation, while in the valley of the Thames these strata do not measure over 250 to 290 feet, showing a rapid thickening to the northward. This augmentation of volume of essentially calcareous deposits in this direction might however be expected from the similar thickening of the Onondaga formation."

Portage-Chemung Formation

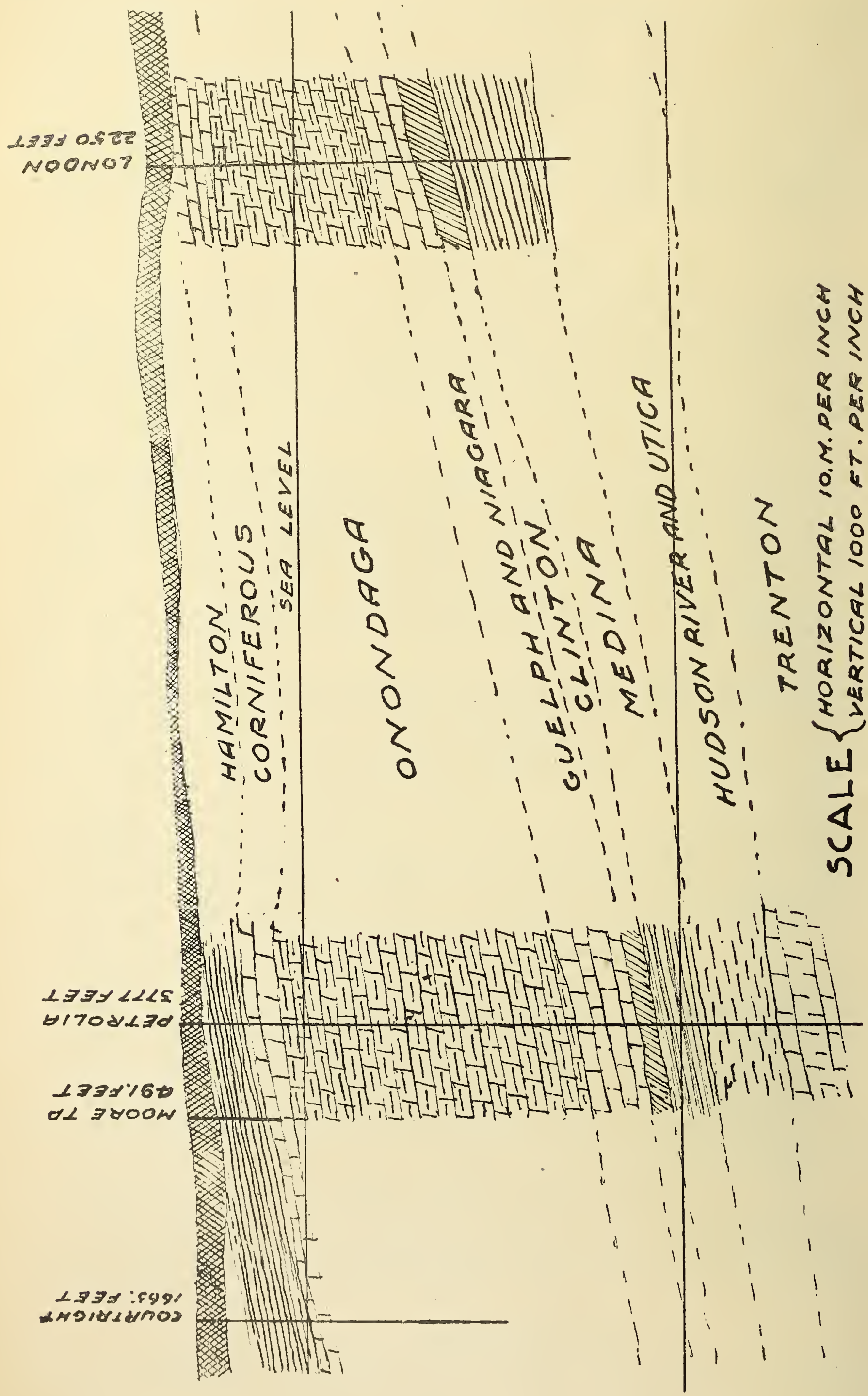
This formation is made up of dark bituminous shales holding in places large calcareous concretions and also much iron pyrites, the shales being often coated with a yellow rust of oxalate of iron. Exposures are seen at Kettle point in Bosanquet township. There is no record of these hard black shales having been met with in any boring in Enniskillen except in those unproductive ones to the north of Petrolea. A great similarity exists between the shales in the upper series of the Hamilton and the lower shales of the Portage-Chemung.

BORINGS FOR OIL AND GAS.

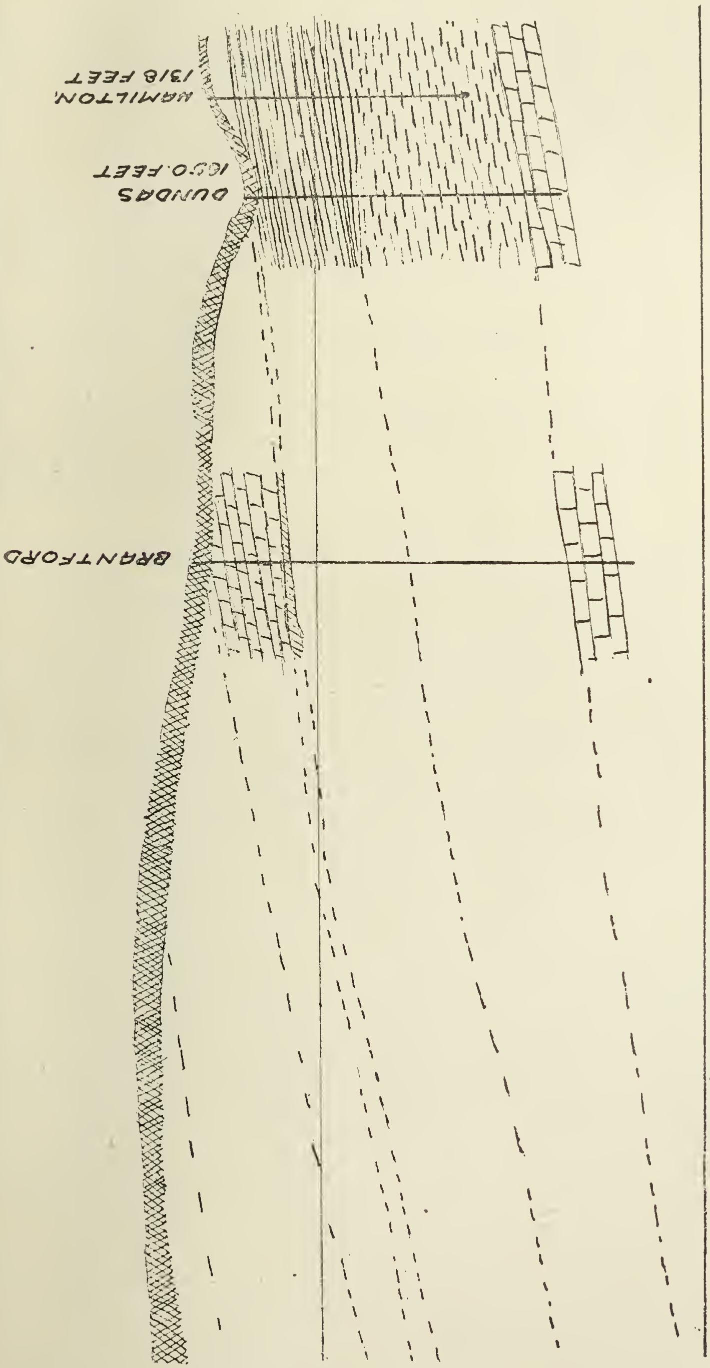
In the following pages is given a partial record of boring operations carried on in those counties of the Province which have proved productive of petroleum and natural gas.

Welland County

Welland county is the most easterly county in Ontario in which natural gas has been found in commercial quantities. This county may be said to have the largest flow of gas, and the most lasting, of any county in the Province.



Section from Hamilton to Courtright.



Section from Hamilton to Courtright (Continued)

Gas is here found in three different formations, namely:

(1) Clinton. (2) Medina. (3) Trenton.

The gas in the Clinton is found in the first twelve feet of the formation.

In the Medina the gas is found (1) in the upper part of the red Medina sandstone, (2) in the upper white Medina sandstone, (3) and (4) in two horizons in the lower white Medina sandstone, about twenty and thirty feet below the preceding horizon in the upper white Medina.

In the Trenton the gas is found 600 feet below the top of the formation, at a depth of 2,330 feet below tide.

The old Welland field, in Humberstone and Bertie townships, has been described by Mr. Brumell,[16] and also by Mr. Coste,[17] so that it is not necessary to do more than give the logs of some of the wells by way of comparison with those of the new fields.

The following logs of wells drilled by the Provincial Natural Gas and Fuel Company give a good idea of the various strata which underlie this field and their respective thickness.

Well No. 61, Lot 2, in 4th Con. Willoughby Township; Elevation 610 feet.

Formation.	Strata.	Thickness.	Depth.	Remarks.
Drift	Clay	18 feet to	18 feet.	
Onondaga	Dolomites and shales with gypsum	202 feet to	220 feet.	
Guelph and Niagara	Gray dolomites	220 feet to	440 feet	Salt water at 330 feet.
Niagara shales	Blue shales	50 feet to	490 feet.	
Clinton	White limestones	30 feet to	520 feet	A little gas at 495 feet and a little salt water.
Medina	Red sandstone and shales	73 feet to	593 feet.	
	White sandstone	10 feet to	603 feet.	
	Blue shale	12 feet to	615 feet.	
	White sandstone	18 feet to	633 feet.	
	Red shales	830 feet to	1463 feet.	
Hudson River	Blue shales	717 feet to	2180 feet.	
Utica	Black shales	160 feet to	2340 feet.	
Trenton	White and gray limestones	670 feet to	3010 feet	Gas at 2,940 feet 1,000 lb. rock pressure.
Calciferous	Gray coarse sandstone	19 feet to	3029 feet.	
Archean	White quartz	1 foot to	3030 feet.	

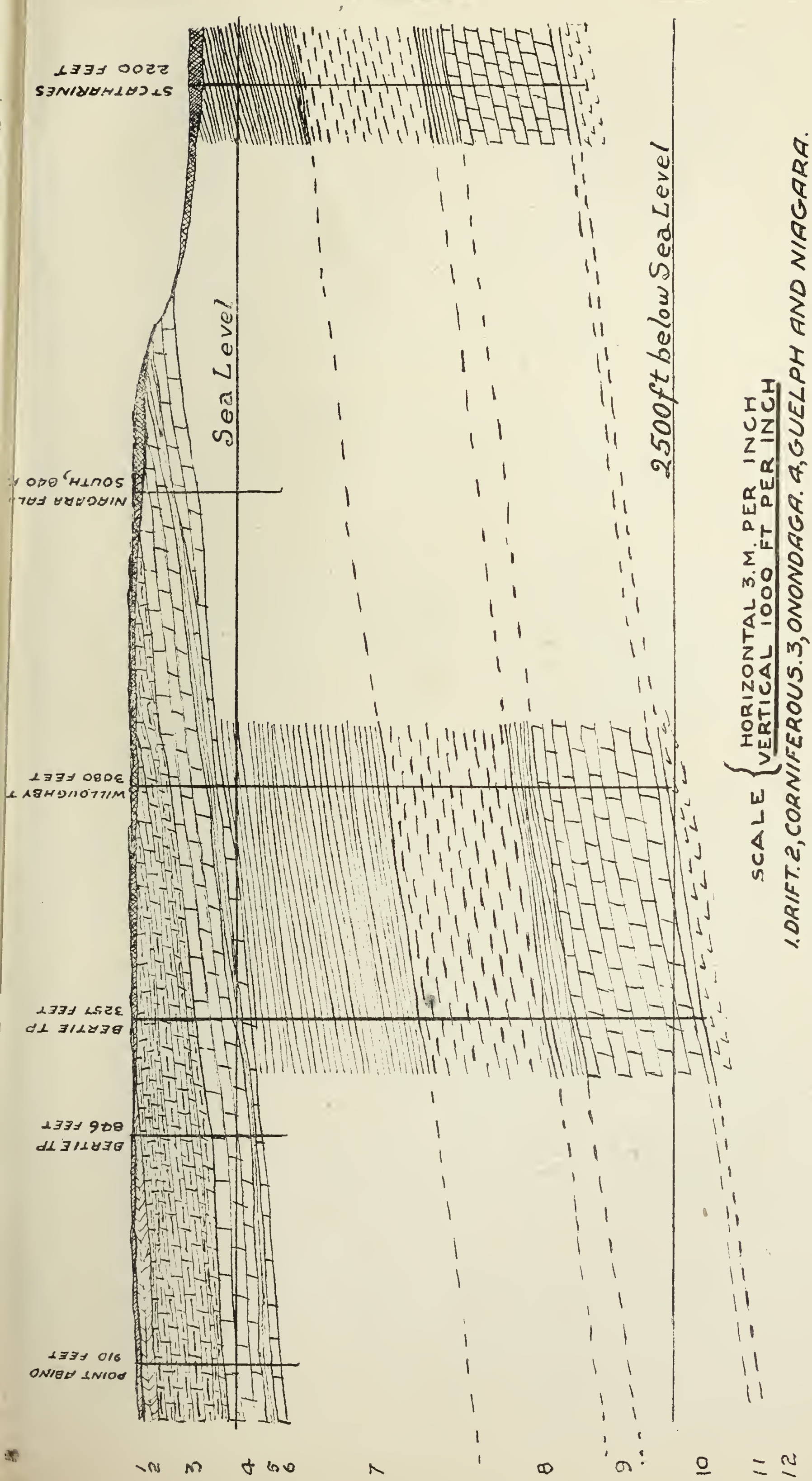
Well on Lot 6 in 15th Con. of Bertie Township; Elevation 605 feet.

Formation.	Strata.	Thickness.	Depth.	Remarks.
Drift	Clay	38 feet to	38 feet.	
Onondaga	Dolomites, gray and drab, black shale and gypsum	300 feet to	338 feet.	
Guelph and Niagara	Gray dolomite	230 feet to	568 feet	Salt water at 470 feet.
Niagara shales	Blue shales	60 feet to	628 feet.	
Clinton	White and gray limestones	32 feet to	660 feet.	
Medina	Red sandstone	83 feet to	743 feet	A little gas.
	Blue shale	15 feet to	758 feet.	
	White sandstone	16 feet to	774 feet.	
	Red shales	850 feet to	1624 feet.	
Hudson River	Blue shales	730 feet to	2354 feet.	
Utica	Black shales	171 feet to	2525 feet.	
Trenton	White and gray limestones	685 feet to	3210 feet.	
Calciferous	Yellowish sandstone	45 feet to	3255 feet	A little salt water.
Archean	Mica schist	2 feet to	3257 feet.	

Well on Point Abino, Bertie Township; Elevation, 580 feet.

Formation.	Strata.	Thickness.	Depth.	Remarks.
Drift	Sand	10 feet to	10 feet.	
Corniferous	Gray limestones with flint	82 feet to	92 feet.	
Onondaga	Gray and drab dolomite, blue shales and gypsum	288 feet to	480 feet.	
Guelph and Niagara	Gray dolomites	235 feet to	715 feet	Gas in large quantities at 500, 530 and 580 feet.
Niagara shales	Blue shales	55 feet to	770 feet.	
Clinton	White limestone	30 feet to	800 feet.	
Medina	Red sandstone	80 feet to	880 feet.	
	Blue shale	13 feet to	893 feet.	
	White sandstone	17 feet to	910 feet	Gas at 902 feet.

16 Rep. Geol. Sur. Can., 1890-1, page 330. 17 Journal Can. Min. Inst., Vol. III., p. 77.



SCALE { HORIZONTAL 3.M. PER INCH
VERTICAL 1000 FT PER INCH

1. DRIFT. 2, CORNIFEROUS. 3, ONONDAGA. 4, GUELPH AND NIAGARA.
5. NIAGARA SHALES. 6, CLINTON. 7, MEDINA. 8, HUDSON RIVER. 9, UTICA.
10, TRENTON. 11, CALCIFEROUS. 12, ARCHEAN.

SECTION FROM POINT ABINO TO ST. CATHARINES

From the information derived from the logs of a great number of wells drilled in this county Mr. Coste points out the following features:[18]

"1. The strata dip to the south and southeast uniformly at the rate of about 35 feet to the mile except for a small synclinal (about one mile wide and 30 feet deep) the axis of which is about one mile north of No. 22 well at Point Abino.

"2. Salt water was struck in every well in large quantities towards the middle of the Guelph and Niagara formation. A little salt water is also found in the Clinton, in the White Medina gas rock and in the Calciferous, at No. 14, but in none of these formations below the Guelph and Niagara is there anything like a continuous body of salt water, which on the contrary lies there in disconnected small bodies of water.

"3. Besides being found in the strata indicated in the above logs gas was also found in some other wells in large quantity, 5 feet in the Clinton limestone, 10 feet in the red Medina sandstone and in the upper white sandstone of the Medina. Some amber-green color oil of a gravity of 42½ degrees Beaumé was also found in the last few feet of the lower white Medina sandstone at wells Nos. 20, 28 and 62. The gas in that sandstone is generally found 3 feet in from the top of it, but often also another vein is found 9 to 10 feet in."

The Crowland gas field occupies an area of two miles by one and one-half miles, about the middle of the township of Crowland.

The well on lot 12 concession six, township of Crowland is quite typical for the field.

Formation.	Strata.	Thickness.	Depth.	Remarks.
Onondaga	Surface	120 feet to	120 feet.	
	Dolomites and shales	120 feet to	240 feet.	
Guelph and Niagara	Gray dolomites	233 feet to	473 feet	Casing at 475 feet.
Niagara shales	Blue shales	55 feet to	528 feet	
Clinton	White limestone	30 feet to	558 feet	Gas at 538 feet.
Medina	Red sandstone and shales	61 feet to	618 feet.	
	White sandstone	12 feet to	631 feet.	
	Blue shales	11 feet to	642 feet.	
	White sandstone	18 feet to	660 feet.	

This field is operated chiefly by The Provincial Natural Gas and Fuel Company. The gas is piped to Niagara Falls.

Another new field that was opened in 1903 is the Winger field in Wainfleet township. This field comprises practically the fourth and fifth concessions between lots 25 and 31, and has been surrounded with dry holes, showing it to be simply a pool. The gas was first utilized from this field in January 1904, being piped into the mains in the old Welland field.

Log of well No. 4, on lot 31, concession 5, Wainfleet township:

	Feet		Feet
Surface	0—144		
Limestone and shale	144—315,	Onondaga	171
Gray dolomite	315—475,	Guelph and Niagara	160
Blue shales	475—520,	Niagara shales	45
White limestone	520—555,	Clinton	35
Red sandstone	555—615,	Medina	60
Gray shales	615—640,	"	25
White sandstone	640—662,	"	22

Cased off water at 490 feet. Gas found at 640 feet in the white Medina sandstone, with twelve feet of gas sand, and at a rock pressure of 260 lb. Average depth of wells 665 feet.

There are twelve producing wells in this field, eight being owned by the Provincial Natural Gas and Fuel Company, and four by the Niagara Peninsula Power and Gas Company, who are piping the gas to St. Catharines, where it is sold to the St. Catharines and Niagara Power and Fuel Company for distribution through the city. Piping to St. Catharines has not yet been completed.

18 Journal Can. Min. Inst., Vol. III., p. 77.

On a well sunk on lot 6, first concession, township of Wainfleet, the records show the following formations:

	Feet	
Gray dolomites, shales and gypsum	390	Onondaga
Gray dolomite	240	Guelph and Niagara
Blue shale	55	Niagara shales
Dolomite	30	Clinton
Sandstone, red	45	Medina
Shale, red and blue	40	Medina
Sandstone, white	20	Medina

Gas having a flow of 400,000 cubic feet was obtained at 685 feet at the summit of the Clinton. No gas was found here in the Medina.

It has previously been proved that the strata in the old Welland field dip uniformly to the south and southeast at a rate of thirty-five feet to the mile. By a comparison of the last two logs, it is seen that there is a similar dip in the vicinity of the Winger field.

Haldimand County

Explorations for gas have been carried westward from the Welland county fields to this county with fairly good results. In 1902, there were nine producing wells in the vicinity of Dunnville. The Attercliffe field, about five miles northeast of Dunnville in the northern parts of the townships of Moulton and Canborough, is the most important in the county, although several producing wells have been put down outside this field. The Dominion Natural Gas Company have thirty-four wells in this field and five wells in other parts of the county. The Citizens' Natural Gas Company of Dunnville have nine producing wells in this field.

Log of well No. 3 on lot 18 in the second concession from Canborough.

	Feet	
Surface (clay)	100	Upper shales, probably Onondaga
Shale and rock	318	Guelph and Niagara
Gray shale	45	Niagara shales
Dolomite	23	Clinton
Sandstone, red	48	Medina
Blue shale	48	"
White Medina	10	"
Red shales	depth of 26	
	618	

The gas is found in the white Medina at a depth of 582 feet, with a flow of 12,000 to 13,000 cubic feet per day.

Log of well No. 2 on the Mansell McCallum farm one-half mile south of Darling road station on the Wabash railway, Canborough township.

	Feet Feet	Feet	
Surface	0—56		
Limestone, shale and gypsum	56—346	290	Onondaga
Gray dolomite	346—506	140	Guelph and Niagara
Blue shale	506—546	40	Niagara shales
Dolomite	546—564	33	Clinton
Gray shale	564—579		
Sandstone, red	579—619	40	Medina
Gray shales	619—649	30	"
Sandstone, white	649—669	20	"
Red shales	669—725	20	"

Gas in white Medina at 665 feet having a flow of 72,000 feet per day. Water was found in the Onondaga and Niagara.

Log of well No. 1 on the farm of K. S. Robbins, one and one-half miles west of McCallum's well, North Cayuga township.

	Feet Feet	Feet	
Clay	0—58		
Limestone and shale	58—358	300	Onondaga
Gray dolomite	358—518	160	Guelph and Niagara
Blue shales	518—558	40	Niagara shales
Dolomite	558—573	25	Clinton
Gray shales	573—583		
Sandstone, red	583—623	40	Medina
Gray shales	623—663	40	"
Sandstone, white	663—680	17	"
Red shale	680—790	110	"

Gas is found at 667 feet in the white Medina sandstone, having a flow of 60,000 feet per day.

A comparison of the logs of the last four wells shows the several strata to have a respective thickness in feet as follows:

	No. 1	No. 2	No. 3	No. 4
Clay	58	56	100	144
Limestone and shales	300	290	318	171
Gray dolomite	160	140	...	160
Blue shales	40	40	45	45
Dolomite / Gray shales	25	33	23	35
Sandstone, red	40	40	48	60
Gray shales	40	30	48	25
Sandstone, white	17	20	10	22
Red shales	110	56	26	..

All of the wells were put down to the red shales and there left unfinished.

In comparing the logs of the three wells given in Haldimand county, and the log of well on lot 31, concession 5, Wainfleet township, all being practically on a line running east and west, and the wells on the extremities of this line being sixteen miles apart, we find the depth of the white Medina sandstone in which the gas is found at depths of 667, 656, 582 and 640 feet respectively from west to east, or 51, 53, 6 and 60 feet respectively below tide. This shows that between wells 2 and 4 there is a slight anticline. Well No. 3 is in the Attercliffe field. This field is therefore on an anticline having a total height of about 60 to 65 feet. Sufficient logs were not obtained to determine its axis or dip.

Some wells have been drilled in the town of Dunnville, gas being obtained in small quantity in nearly all. One well put down by citizens in the town averaged a pressure of 100 lb. for seven months. Gas is found here in the White Medina sandstone at a depth of 800 feet.

The strata in this county dip uniformly to the south thirty-one feet to the mile.

Gas is piped by the Dominion Natural Gas Company from their wells in Haldimand to Hamilton and Dundas, a pressure of 60 lb. being obtained at Dundas. The main pipe line is an 8-inch line running from Canfield in Cayuga township through to Seneca township, and the small towns of Blackheath, Binbrook and Rymal to Hamilton. Another small line carries it from Hamilton to Dundas. Smaller pipe lines from the company's wells in Cayuga and Canborough supply the main line. Gas is also piped to Dunnville by both the Dominion and Citizens' Natural Gas Companies.

Brant County

Explorations for gas in this county were carried on in 1888, and two wells were drilled, one being put down to the Trenton. The boring, however, as far as has been recorded, was unsuccessful. In 1903 drilling for gas was again undertaken in the city of Brantford, and six or seven wells were put down, four being on the Cockshutt property. A strong flow of gas was obtained, and used in the furnaces of the Cockshutt manufacturing works. The pressure after some time began to lessen until the supply was not sufficient to keep the furnaces going. It was then found that oil had oozed into two of the wells. These are now producing about eighteen barrels per month. In one well drilled by the Cockshutts a pocket of gas was struck which at first yielded 775,000 cubit feet per day, diminishing to 12,000 to 15,000 feet per day.

Log of Cockshutt well No. 3:

	Feet	
Surface		
Sandy loam	7	
Wash gravel	3	
Clay	40	
Quicksand	21	
Hard pan	11	
Limestone, &c	283	Guelph and Niagara
Black shales	45	Niagara shales
Dolomite	12	Clinton sand
Red shales	45	Medina
Gray shales	45	"
Sandstone	20	"
Red shales	88	"

Gas and oil are found in the Medina sandstone at a depth of 512 feet.

Record of well drilled by Gould, Shapley and Muir Co., on Wellington street, Brantford:

	Feet		Feet.
Surface	0—61		
Limestone, etc	61—360	Guelph and Niagara	299
Black shales	360—405	Niagara shales	45
Dolomite	405—425	Clinton	20
Sandstone, red	425—460	Medina	65
Blue shales	460—490	"	30
Sand rock	490—505	"	15
Sandstone, white	505—515	"	10
Red shales	515—670	"	155

Gas was struck at a depth of 610 feet, and according to the record obtained from the driller, in the Medina red shales, 100 feet below the horizon in which the gas is found in other wells in this district. The rock pressure at first was 265 lb. The well is now flowing 15,000 cubic feet per day. It is altogether probable that as the gas pressure decreases in this well oil will begin to come in.

The discovery of gas and oil at Bow Park Farm, two miles southeast of Brantford is described in the Thirteenth Report of the Bureau of Mines. Development work has been steadily going on since that time and ten wells in all sunk, one of them being put down to the Trenton.

Log of well No. 4 on Bow Park Farm:

	Feet		Feet.
Surface	0—72		
Limestone, etc	72—365	Onondaga, Guelph and Niagara	293
Black shales	365—415	Niagara shales	50
Dolomite	415—430	Clinton	15
Red shales	430—475	Medina	45
Blue shale	475—505	"	30
Gray sand (hard)	505—525	"	20
Sandstone, white	525—532	"	7
Red shales	532—624	"	92

First gas struck at 420 feet in the Clinton.
Second gas struck at 530 feet in the Medina white sandstone.
Oil struck at 542 feet in the Medina red shales.

The logs of the wells drilled on this farm are very similar, the greatest variation being in the thickness of the white Medina sandstone.

Logs of wells No. 6, 7, 8 and 9 on Bow Park farm:

	No. 6 ft.	No. 7 ft.	No. 8 ft.	No ft.
Surface	87	45	91	97
Onondaga, Guelph and Niagara limestone	292	276	300	290
Niagara black shales	45	45	45	45
Clinton dolomite	20	15	23	23
Medina red shales	30	30	31	35
Medina blue shales	30	35	30	35
Medina gray sand	20	25	30	15
Medina sandstone, white	13	10	....	11
Medina red shales	111	135	203	80
	650	616	753	630

In No. 6 gas was struck at 430 feet in the Clinton, and at 538 feet in the Medina white sandstone. Oil was struck at 590 feet or 63 feet in the Medina red shales.

In No. 7 a very small flow of gas was obtained at 479 feet in the Clinton.

In No. 8 a flow of gas was obtained at 439 feet in the Clinton. From the log it is seen that the Medina white sandstone is entirely lacking in this well, which will account for no gas being found below the Clinton in the depth drilled.

In No. 9 gas was found at 436 feet in the Clinton sandstone, and at 549 feet in the Medina white sandstone. Oil came in 60 days after the well was drilled.

This field is similar to the Dunnville and Attercliffe field in that the gas is obtained from the Clinton and white Medina sandstone. The chief supply of gas comes from the latter, the top of which is at an average depth of 530 feet or about 150 feet

of an elevation above tide. The top of the white Medina sandstone in the gas district of Haldimand county is found at an elevation of about 45 feet below tide. There is therefore a difference in elevation of about 195 feet, or a uniform dip of the white Medina sandstone to the south of nine to ten feet per mile.

The Trenton formation is struck on Bow Park Farm at a depth of 1,930 feet or an elevation of 1,250 feet below tide. The Trenton is encountered in Welland county at an elevation of about 1,750 feet or 500 feet lower than at Brantford, showing the Trenton also to have a south and southeasterly dip, with some of the lower strata increasing in thickness in a southeasterly direction.

The gas from the wells at Bow Park Farm has been piped to Brantford and leased to the Imperial Natural Gas Company, who supply the city.

Two or three of the wells have been shot, but the flow did not appear to be increased.

The Provincial Natural Gas Company drilled three holes northeast of Bow Park, but nothing was struck.

Norfolk County

Following is the record of a well drilled at Port Rowan in the county of Norfolk:

Depth.	Formation.	Color.
0— 300		Surface Clay.
300— 363	Corniferous	Gray limestone.
363— 440	"	Grayish-blue limestone.
440— 470	"	Dark brown.
470— 564	"	Bluish gray.
564— 585	Corniferous or Oriskany	White and blue granular limestone.
585—1,020	Onondaga	Grayish-blue dolomite.
1,020—1,310	Niagara	White sugary limestone.
1,310—1,320	Clinton	Drab and argillaceous limestone.
1,320—1,460	Medina	Red and blue sandstone.

Elgin County

Drilling for oil was first begun in this county about forty years ago. About eight years ago a deep well was drilled at St. Thomas to a depth of 3,030 feet. A very little gas was found in the Medina, but salt water was encountered and the well was of no importance. About the same time drilling was begun in the township of Dunwich about 20 miles west of St. Thomas. This is the Dutton field and is about five miles south of the village of that name.

The field comprises in all about 400 acres, and 154 wells have been drilled in it, 68 wells by the Elginfield Oil & Gas Developing Co., 73 wells by the Beaver Oil Co., and 13 by the Talbot Oil Co. The oil is found in the Corniferous at a depth in it of 160 to 175 feet. The best wells are obtained when the Corniferous is struck 245 to 250 feet from the surface.

Log of a well of the Elginfield Oil & Gas Co.:

Surface	200 feet	
Black shales	6-7 feet	Hamilton
Hard pan, Blue clay	25 feet	Hamilton
Limestone	170 feet	Corniferous
Total depth	402 feet	

Oil was struck at a depth of 160 feet in the Corniferous, and 9 feet of oil rock passed through.

Log of wells drilled by the Beaver Oil Co.:

Surface	228 feet	
Lime (gray shales)	25 "	—Hamilton
Limestone	187 "	—Corniferous.
Total depth	440 feet.	

Oil found at 175 feet in the Corniferous.

	Feet.	
Sur ace	208	
Lime (shales)	27	Hamilton.
Limestone	172	Corniferous.
Total depth	40	

Average of 16-18 feet of "cuttings" (oil rocks.)

Some wells have no shale overlying the Corniferous.

	Feet	
Surface	183	
Limestone	167	Corniferous.

The best wells in the field are found where there is 25 to 30 feet of shale overlying the Corniferous lime. It would thus appear that there is a series of auxiliary anti-clines running through the field.

The wells in the Dutton field are different from those in the Petrolia field, although oil in both fields is found in the Corniferous. In the latter field oil is struck 65 to 70 feet below the surface of the Corniferous, while in the former oil is found from 160 to 170 feet in it. The wells are similar to the Petrolia wells in that they are small but steady producers.

All the wells are shot with fifteen quarts of nitro-glycerine.

Log of a well twenty miles west of Dutton at Clearville:

	Feet.	
Surface	167	
Soap (shales)	183	Hamilton.
Limestone	165	Corniferous.

Salt water was struck.

In the eastern part of this county a few wells were drilled in 1903 which produced some oil.

Log of well near Aylmer, township of Malahide:

Surface clay, sand and gravel	247 feet
Corniferous lime	169 "

A little surface oil was struck at 247 feet, and also a little at 278 feet. At 386 feet, or 139 feet in the Corniferous, oil was found which yielded three barrels per day. This is a very light oil with a gravity of 41 degrees Baumé.

Kent County

Many wells have been drilled in this county in search of both gas and oil, principally in the years following the discovery of oil at Petrolia and Oil Springs, also in latter times in search of gas, so far unsuccessfully except for small quantities.

The Bothwell field is probably the most steady producer of oil of any field in the county. It is situated in the northern part of Zone township between the Grand Trunk Railway and the Thames river, about two and one-half miles west of the village of Bothwell. The Walker Gas and Oil Company, Windsor, and Fairbanks and Carman, Petrolia, are the principal operators. The former company have sunk about ninety wells having an average depth of 600 feet. These wells produce 15,000 barrels of oil a year, and the production is said not to depreciate more than two per cent. each year. To offset this four new wells are put down each year.

Well at Bothwell:

	Feet.		Feet.
Surface	155		
Soapstone	31	Hamilton	67
Shale, black	4		
Soapstone	32		
Limestone	148	Corniferous.	

The total number of producing wells is from 250 to 300, but new ones are continually being sunk. The yield of oil is from 5,000 to 6,000 barrels a month for the whole oil field.

Log of well at Bothwell:

	Depth. Feet.		Feet
Quicksand	15— 15		
Clay	45— 60		
Running Gravel	85—145		
Clay	10—155	Surface	167
Quicksand	5—160		
Hard pan	7—167		
Middle lime	10—177		
Soapstone	16—193	Hamilton	36
Lime	8—201		
Lower lime	178—381	Corniferous.	

Some water and oil obtained at 210 feet; began to show oil at from 345 to 350 feet, but from 365 to 376 feet the limestone is quite coarse and oil washes out. The well was shot with sixteen quarts of nitro-glycerine from 365 to 376 feet. Oil is therefore found in the Corniferous at a depth of 188 feet. The Hamilton formation in this field has been greatly eroded, being about 200 feet less in thickness than at Petrolia or Thamesville.

At Thamesville about seven miles west of the Bothwell field a number of wells have been put down, yielding oil in some cases. Dr. Hunt gives the log of a well at this place as follows:

	Feet	
Clay	60	
Gray shale, etc.	240	Hamilton.
Gray limestone	32	Corniferous.

Oil was found at sixteen feet in the Corniferous.

Another well drilled recently by Messrs. Fairbank and Company of Petrolia gives the log as follows:

	Feet.		Feet.
Sand	4— 4		
Blue clay	50— 54	Surface	69
Stones	15— 69		
Black shale	10— 79		
Top rock	40—119		
Soap	130—249	Hamilton	237
Middle lime	14—263		
Soap	33—296		
Lower lime	146—442	Corniferous.	

Oil and gas were found at depths of 356 and 427 feet, or at 60 and 131 feet in the Corniferous. This well is almost identical with wells drilled in the Petrolia field with the exception of a smaller thickness of surface.

On lot 19 in the fifth concession of Dover township near Chatham a well has been put down to a depth of 500 feet.

	Feet.		Feet.
Sand	15		
Clay	50		
Shale	60		
Top rock	40		
Soap	120	Hamilton	270
Middle lime	15		
Lower soap	35		
Lower lime	105		
White sand rock	45	Corniferous	167
Dark sand rock	17		

Salt water was struck at 350 and 400 feet respectively.

[19] Geol. Survey of Canada 1863, p. 247.

Another well which Mr. H. P. H. Brumell describes[20] was drilled one mile northwest of the Grand Trunk Railway station at Chatham:

	Feet.	
Surface clay	60	
Shale, black	118	
Soapstone	200	Hamilton.
Limestone (middle lime)	18	Hamilton.
Soapstone	37	Hamilton.
Limestone	567	Corniferous.

Part of this black shale is likely to belong to the Portage-Chemung. The Hamilton averages about 30 feet in thickness, and the upper black shales of the Hamilton and lower shales of the Portage-Chemung are very similar. The record given shows the limestone below the Hamilton to have a thickness of 567 feet. This is a greater thickness than has been found in the Corniferous. The lower layers are therefore in all probability a dolomite belonging to the Onondaga.

Oil was struck in a well on lot 18 in the twelfth concession of Raleigh township in November of 1902. This well was called the "Gurd gusher" and produced during its flowing period about 1,000 barrels per day. Many wells were drilled in the vicinity, but with little success. At the present time there is nothing being done in the field. The "gusher" ceased to flow, and pumping has been stopped.

This field is described by Prof. Miller,[21] from whose report the following log has been taken. The well is on lot 19, concession 14, township of Raleigh.

	Feet.		Feet.
Boulder clay	184		
Shale ... to	205	Hamilton	94½
Limestone (argillaceous) ... to	211	Hamilton	
Shale ... to	240	Hamilton	
Limestone ... to	246	Hamilton	
Shale ... to	247	Hamilton	
Limestone (middle lime) ... to	249	Hamilton	
Shale ... to	278½	Hamilton	
Limestones, very slightly argillaceous ... to	511	Corniferous	232½

The last is called the "big lime" or "lower lime."

The Wheatley field in the vicinity of Wheatley village in Romney township is a small producer. The United Gas and Oil Company have four wells on lot 11 in the second concession, which yield an average of ten barrels per day. These wells are sunk to a depth of 1,298 feet. The water is shut off at a depth of 595 feet in the Niagara. About 400 feet of salt, called by the drillers the "big salt" is also obtained. A very hard gray limestone overlies the oil strata. The oil is found in the Guelph formation.

Lambton County

This county has been for many years the foremost and was for some time the only oil producing district in the Dominion. The Petrolia and Oil Springs fields have been fully described by Mr. H. P. H. Brumell,[22] consequently the writer will confine himself to a brief mention of the more recent operations in the county.

Mr. Brumell writes as follows:

"The oil of Lambton county is, in the main, obtained from two distinct pools known as the Oil Springs and Petrolia fields, both in the township of Enniskillen. The larger of the two—the Petrolia field—with an approximate area of twenty-six square miles, extends W. N. W. about nine miles and E. S. E about four miles from the village of Petrolia; while the Oil Springs field covers about two square miles and includes the south eastern part of the village of Oil Springs."

A new field can now be added to these two, which bids fair to become a good producer. This is the Moore field, and comprises approximately lots 1 to 5 in the ninth,

[20] G. S. C., 1890-91 Report, p. 73 Q [21] Thirteenth Rep. Bureau of Mines, 1903, page 40.
[22] G.S.C., 1890-91, page 61 Q.

tenth and eleventh concessions of the township of Moore. The best wells are located on lots 3 and 4 in the ninth and tenth concessions. This field was opened up by the Moore Oil and Gas Company in July, 1904, and is about four miles west of Petrolia.

Log of the Davis well drilled by the Moore Oil and Gas Company on lot 3 in the tenth concession of Moore township near the old Sarnia plank road:

	Feet.		Feet.
Surface	148		
Top rock (upper lime)	45	Hamilton	232
Shale (upper soap)	125		
Limestone (middle lime)	15		
Shale (lower soap)	47		
Limestone (lower lime)	111	Corniferous.	
Total depth	491		

Supply of gas struck at 400 feet. Oil struck at 445 to 450 feet at a depth of 65 to 70 feet in the Corniferous.

This well, which was the second well in the field drilled, started out with a production of 100 barrels per day.

Log of well drilled by Fairbanks and Carman:

	Feet.		Feet.
Surface	143		
Top rock	48	Hamilton	240
Soap	130		
Middle lime	15		
Soap	42		
Streak of lime	3		
Soap	2		
Lower lime	68	Corniferous.	

The Corniferous formation was encountered at a depth of 384 feet, and oil found at 395 feet and 410 feet.

Details of the Corniferous formation in the above well are as follows:

Feet.	
395	Crystalline limestone.
400	Gray.
402½	Gray.
405	Gray, no oil.
407½	Soft.
410	Rock well browned up with oil.
412	Gray.
417½	Crystalline.
422½	Soft, browner, more crystalline.
425	Gray, oil came in.
427½	Hard.
430	Brown and sandier.
437½	Crystalline.

The Moore field is quite clearly defined by a black shale which is found south, east and west of the field at depths of 127, 100 and 132 feet respectively. In the field the top rock is at a depth of 147 to 154 feet. No producing well has been found where the black shale overlies the top rock. The "lower lime" in the wells on the edge of the field is met at a greater depth than in the middle of the field, proving quite conclusively the presence of an eroded anticline. This black shale is in all probability the upper strata of the Hamilton, which at Petrolia assumes a thickness of 296 feet.

North of the field, no shale is found overlying the "top rock" for some distance, and a few producing wells have been located. It has been thought that the oil belt ran in a direction northwest by southeast, but in this field it runs rather in a southwesterly by northeasterly direction and quite irregularly, except that as the shale is neared the wells diminish in production.

The oil is found in two horizons from fifteen to twenty feet apart of about eight to ten feet thickness. The wells are connected as shown by the fact that some wells drilled the width of 100 acres from a producing well have reduced the flow of the latter. From fifteen to twenty wells have begun pumping from 40 to 100 barrels per day. In March, at the time of the writer's visit to this field, there were twenty drilling rigs at work.

All the wells are shot with from thirty to forty-five quarts of nitro-glycerine.

In this field there is also considerable gas which is used as fuel for pumping and drilling on most of the properties.

Mr. Brumell writes regarding the Petrolia wells as follows:[23]

"The oil horizon at Petrolia lies at a depth of from 450 to 480 feet beneath the surface of the main part of the town, the oil being pumped in all instances from what is known as the 'lower vein' at a point about 65 feet in the Corniferous limestone. The following record may be taken as typical of the wells sunk in the Petrolia field."

Well sunk near the Imperial Refinery, Petrolia:

	Feet.		Feet.
Surface..	104		
Limestone (upper lime)	40	Hamilton	228
Shale (upper soapstone)	130		
Limestone (middle lime)	15		
Shale (lower soap)	43		
Limestone (lower lime)	68	Corniferous..	133
Limestone, soft....	40		
Limestone, gray	25		

Following is the log of a well that was sunk at Petrolia to the Trenton line:

Carman well No. 1, lot 11, concession 11, Enniskillen, Lambton county, Ontario, R. I. Bradley estate, Elev. A. T. 667 feet:

			Feet.	Feet.
HAMILTON		Surface blue clay	90 —	90
		Streaks lime and shale	240 —	330
CORNIFEROUS		Corniferous	190 —	520
ONONDAGA	SALINA.	Streaks brown, gray and black dolomite	690 —	1,210
		Salt	65 —	1,275
		Dolomite	20 —	1,295
		Salt and thin streaks dolomite..	140 —	1,435
		Dolomite	30 —	1,465
		Salt..	90 —	1,555
		Salt with light and dark streaks dolomite	50 —	1,605
		Salt..	25 —	1,630
		Gray dolomite lime	10 —	1,640
		Salt..	67 —	1,707
		Streaks dolomite and salt	40 —	1,747
		Salt..	138 —	1,885
		Gray dolomitic lime and shale..	130 —	2,015
		Salt....	90 —	2,105
CLINTON		Guelph and Niagara dolomitic lime..	275 —	2,380
		Niagara shale (red and dark)..	60 —	2,440
		Clinton	90 —	2,530
MEDINA		Red Medina	275 —	2,805
UTICA		Hudson River shales (light)..	205 —	3,010
		Utica (dark)	165 —	3,175
TRENTON		Trenton	170 —	3,345
		Bird's Eye..	115 —	3,460 } 602
		Chazy..	317 —	3,777

Thirteen-inch conductor, 98 feet; $7\frac{5}{8}$-inch casing, 186 feet; $6\frac{1}{4}$-inch casing, 1,015 feet.

In the Oil Springs field, oil is found at a depth of about 370 feet or 60 to 65 feet below the summit of the Corniferous. The shallowness of the wells as compared with those at Petrolia is due to the thinner mantle of surface drift, and also to a diminished thickness of the Hamilton formation, as shown by the following log:

	Feet.		Feet.
Surface	60		
Limestone (upper lime)	35	Hamilton	170
Shale (upper soapstone)	101		
Limestone (middle lime)	27		
Shale (lower soap)	17		
Limestone (lower lime)	130	Corniferous.	

Another well drilled at Oil Springs gave the following log:

	Feet.		Feet.
Blue clay	58		
Top rock	55	Hamilton	209
Soap	109		
Middle lime..	15		
Soap	30		
Lower lime	131	Corniferous.	

[23] G.S.C. Report, 1890-91, page 61 Q.

Another field in the southern part of the county in Euphemia township is a small producer. Very little is being done here at present, but a little oil is being pumped.

The log of a well in this township gives:

	Feet.
Surface	53
Hamilton	224
Corniferous	93

Oil is found in the Corniferous at depths of 90 to 100 feet.

According to Mr. Coste[24] oil has also been found in the Oriskany sandstone, which underlies the Corniferous, in this field. This is the only record we have of oil having been found in this formation.

Log of well drilled by Fairbanks and Carman in Euphemia township:

	Feet.		Feet.
Surface clay	48		
Top rock	50	Hamilton	218
Soap	130		
Middle lime	20		
Soap	18		
Lower lime	120	Corniferous.	

Oil is obtained at about 100 feet in the "lower lime."

Log of well drilled in the township of Dawn:

	Feet.	
Surface clay	38	
Streaked with lime	20	Hamilton 199 feet.
Soap	128	
Middle lime	20	
Soap	25	
Lime	4	
Soap	2	
Lower lime	100	Corniferous.

Oil was struck at a depth of 87 feet in the Corniferous.

Essex County

Explorations in this county until very recently have been mainly in search of natural gas, which was first proved to exist in this county in large quantities in January, 1889. Many wells have been drilled in various parts of the county, chiefly in the district between Kingsville and Leamington and in Colchester township.

Probably the largest flow of gas obtained from any well was from Coste well No 1 in the northwest corner of lot 7 in the first concession of the township of Gosfield, which is thus described by Mr. Coste:[25]

Soil	0 feet to 5 feet.	
Drift, gray sand	5 " 120 "	
Brown and gray dolomitic limestones, with gypsum and with white and black flint.	120 " 500 "	Onondaga 900 feet.
Gray blue and shaly dolomites and drab brown dolomites with a good deal of gypsum	500 " 860 "	
Dark brown dolomites and gypsum (with gypsum bed from 970 to 985)	860 " 1020 "	
Gray blue crystalline vesicular dolomite	1020 " 1031 "	Guelph 11 feet.

A little gas was got at 910 feet and 930 feet, but a large quantity at 1,020 feet or at 362 feet below tide. The flow of gas from this well measured, after being first brought in, 10,000,000 cubic feet per day.

A complete log of the measures underlying this county was obtained from a well drilled by the Provincial Natural Gas and Fuel Company on lot 64 in the first concession of the township of Colchester South; elevation 648 feet.

24 Journal Can. Min. Inst., Vol. VI., page 110.
25 Journal Can. Min. Inst., Vol. III., p. 70.

Formation.	Strata.	Thickness.	Depth.	Remarks.
Drift	Sand	20 feet to	20 feet.	
"	Quicksand	90 "	110 "	
Onondaga	Gray and brown dolomitic limestone with flint and gypsum	67 "	177 "	
"	White fine sharp sand	10 "	187 "	
"	White, gray and brown dolomites with white and black flint and with gypsum	203 "	390 "	
"	Gray, blue and brown dolomites (mostly shaly with a good deal of gypsum), shaly group	370 "	760 "	
Guelph and Niagara 215 feet	Blue, white, gray and brown dolomite, quite crystalline and very porous.	215 "	1,125 "	Salt; black salt water at 910 feet and again at 1,010 feet.
Clinton 155 feet	White and white blue limestone	155 "	1,280 "	More salt water at 1 232 feet
Medina 285 feet	Gray blue shale	7 "	1,287 "	
"	Gray blue limestone	5 "	1,292 "	
"	Green shales	8 "	1,300 "	
"	Red pink shales.	5 "	1,305 "	
"	Gray blue unctuous shales	88 "	1,393 "	
"	Gray blue and white sandy limestones	62 "	1,455 "	
"	Red pink shales	110 "	1,565 "	
Hudson River	Gray blue lime shales with shells of lime	350 "	1,915 "	
Utica	Brown and black shales	235 "	2,150 "	
Trenton	White and dark gray limestones	270 "	2,420 "	A little gas and oil at 2,150 feet.

Mr. Coste points out[24] the principal features revealed by the drilling in this county to be as follows:

"1st. In the south and southeast part of the county of Essex along lake Erie the first stratum met with under a heavy sand drift is the Onondaga and not the Corniferous, as it was supposed and as shown on the geological maps.

"2nd. Between the Coste well No. 1 and well No. 3 of the Ontario Natural Gas Company, in a distance of three-quarters of a mile, there is a dip of 80 feet. This, as shown by the logs of other wells between these two, is due to a fault in the strata running in a direction W. N. W. and E. S. E., and passing only a little to the north of Coste well No. 1. The logs of other wells to the west of Coste well No. 1 have also revealed another fault running a short distance west of that well in a direction at right angles to the fault above mentioned.

"3rd. An extensive bed of gypsum 10 to 20 feet thick has been regularly found in the lower part of the Onondaga formation. This bed underlies the greater part of the county of Essex.

"4th. Oil and gas * * * are known to exist in many parts of the country and in a number of different strata.

"5th. Large quantities of salt water are always found in Essex county in the Guelph, and Niagara and in the Clinton.

"6th. The Oriskany sandstone is well developed in the western and northern parts of the county, but is missing in same parts of it as shown by the record of well No. 1 of the Union Gas Co."

Drilling operations are at the present time in Essex county confined chiefly to Mersea township in an area about six miles east of the most productive gas wells at Ruthven. As stated before, oil was found near Leamington in 1902, but the first few months of 1905 has witnessed the bringing in of some large producers in this belt.

As far as yet discovered, the productive area extends from concessions one to nine in the township of Mersea, and has a width of about 1,000 feet, chiefly on lots 9 and 10 on these concessions and lot 238 Talbot road.

No detailed log of any of the oil wells here was obtained, but the logs apparently are very similar to those in Gosfield township.

Log of well drilled by Fairbanks and Carman at Leamington:

Sand	10 feet	Surface 100 feet.
Clay	80 "	
Gravel	10 "	

Limestone was struck at about 100 feet which continued together with gypsum and dolomite formations to the finish of the well at 1,091 feet. Fresh water was cased

[24] Journal Can. Min. Inst., Vol. III, page 74.

off at 710 feet. Some gas was met with at 765 and 960 feet and gradually increasing to 1,060 feet. At 1,080 feet sprayed oil, the flow of which increased at 1,082 feet. The gas was very strong at 1,070 feet, blowing cuttings out of the hole, and at 1,080 feet probably made one million feet per day. The well was deepened to 1,091 feet and showed but little water until it had flowed a number of days.

The oil comes from the Guelph formation at a depth of about 1,040 feet in the southern end of the field, and about 1,125 feet in the northern part.

The Leamington Oil Company, which is the oldest concern in the field, completed its twenty-first well on March 20th, 1905. Out of these twenty-one wells, eighteen are productive.

The United Oil and Gas Company have seven producing wells out of eleven put down.

The Detroit and Leamington Company have three producing wells.

The Detroit and Dominion Company have one producing well. This is the Jackson well, which started flowing 400 barrels a day after being shot, in a few days settling down to 100 barrels a day.

The Hickey Oil Company have four producing wells. The Hickey No. 1 was shot 1st December 1904, and flowed for one month. The Hickey No. 4 on the Wales farm, one and one-half miles north of the Jackson gusher, started off at the rate of 1,200 barrels a day, but later settled down to about 200 barrels a day.

The British America Company have one producing well.

The South Essex Oil and Gas Company have a producing well on lot 10, south of the Talbot road.

The Major Syndicate have two wells on lot 10 in the first concession of Mersea township, producing on an average five barrels per day.

The Lake Orion Oil and Gas Company have one producing well, which began to flow at the rate of 150 barrels per day. This is on the farm directly north of the Wales farm, on which the Hickey gusher is located.

The Buffalo and Leamington Company have one producing well on lot 9, concession 9, Mersea. The well has a depth of 1,125 feet. All the wells are shot with about 50 quarts of nitro-glycerine.

In addition to the oil wells there are three or four gas wells, which are in the new oil field north of the old gas field, one of which (No. 3, Rymal) produced at first 1,300,000 cubic feet per day. This well was brought in in February, 1904. These gas wells supply the town of Leamington, and also fuel for drilling and pumping.

At Comber on the Michigan Central Railway, eight wells have been sunk, of which six are producing on an average two barrels per day.

The following is the record of a deep well drilled for the Leamington Oil Co. on Dr. Albert Foster's farm, East Lot 239, North Talbot Road. Commenced March 18th 1905, and completed June 27th:

Feet.	
89	10 feet drive pipe.
585	8 feet casing.
1095	Top salt sand.
1500	Top blue lime.
1556	6¼ feet casing (red rock).
1566	Top slate.
1650	" Clinton lime.
1700	" Red rock.
1850	" slate.
1870	" Red rock.
1950	" lime.
1970	" shale.
2275	" slate.
2488-9	" Trenton rock.
Total depth, 2896 feet	

The well was shot June 24th with 226 quarts of glycerine.

Log of well on lot 7 in the third concession of Tilbury West:

Surface	120 feet	
Limestone	163 "	Corniferous.
Sandstone	20 "	Oriskany.
Limestone and shale	897 "	Onondaga.
Crystalline dolomite	183 "	Guelph.

Oil was struck at 1,200 feet, and nearly 100 feet of oil rock was passed through. The company operating at Comber is the Sovereign Oil Company.

Mr. Brumell[25] cites a well drilled in 1889 at Blytheswood on lot 7, concession 9, Mersea, to the depth of about 1,200 feet. A small flow of gas was obtained at 1,050 feet, followed at 1,150 feet by a heavy flow of salt water. Oil was not found.

This well is just west of a well sunk on lot 9, concession 9, Mersea, the year in which oil was found, further evidence of the narrowness of the productive area in the Leamington oil field.

Pelee Island

Drilling has been carried on for a number of years on this island in search of gas and oil, with a moderate amount of success. Oil has been found at a depth of about 750 feet.

Borings examined by Dr. Ami, of the Geological Survey Department, give:

Surface drift	58 feet
Corniferous and Oriskany	222 "
For the most part impure fossiliferous limestone with corals, shells and carbonaceous matter.	
Measures unrecorded but probably Oriskany sandstone	44 "
Lower Helderberg and Onondaga	458 "
Consisting of gypsum and gypsiferous dolomites, light yellow, dark gray and bluish gray in color.	
Total depth	782 "

[25] G. S. C., 1890-91, page 84, Q.

CEMENT INDUSTRY OF ONTARIO

BY P GILLESPIE

[NOTE.—In the preparation of this article, the following publications were consulted, and the assistance obtained therefrom is gratefully acknowledged: Butler's Portland Cement, Geological Survey of Michigan, Vol. VIII, 1903, Reports of Geological Survey of Canada, Geological Survey of Ohio, 1904, Reports of the American Society for Testing Materials, Vol. II, 1902, and Cumming's American Cements.—P. G.]

"An artificial mixture of lime and clay in proper proportions, calcined to a clinker at a temperature of incipient fusion and finely ground, is called Portland cement" Its manufacture dates from the year 1824, when Joseph Aspdin, a Leeds brickmaker, first put his product on the market. It was designated by him "Portland" cement, from its fancied resemblance when hardened to the well-known colitic limestone quarried on the island of Portland, on the south coast of England, and for centuries used as a building material.

More the result of accident than of purposeful investigation, Aspdin's discovery is like many others of modern times. He mixed the pulverized limestone from the macadamized highways with clay and water. The mixture was dried and burned to a clinker in a kiln. The clinker thus produced was afterwards ground, and its setting and hardening properties on the addition of water rendered it a useful material in construction. In the following year, 1825, he built a factory for its production at Wakefield, and it is said that his cement was employed by Sir I. K. Brunel in 1828 in the construction of the Thames tunnel.

Two years after the registration of Aspdin's patent, Maj.-Gen. Sir C. W. Pasley commenced a series of experiments on artificial cements at Chatham dockyard, which in the light of his time were very gratifying. His raw materials at first were chalk and brick loam, but the supply of the latter having become exhausted, Medway blue clay was substituted, a remarkably good product, everything considered, being the result.

So far as records inform us, these two were the pioneers in an industry which during the last quarter of a century, and especially during the last decade, has grown to gigantic proportions. The chief competitor of the new Portland cement was the so-called Roman cement, which since the time of John Smeaton had been manufactured in England. He it was who first discovered that the cause of hydraulicity in certain limestones is the presence of clay in the stone. That was in 1756. Thenceforward the burning and grinding of nodules of clayey limestone found along the English sea-coast, became a profitable business. The product was known as "Roman cement," analogous of course to modern natural cement, and it was from the manufacturers of this that the greatest early opposition to the introduction of Portland cement came.

Many failures mark the first quarter century of the history of Portland cement, chiefly no doubt to lack of scientific direction, and although public competitive tests had as early as 1843 conclusively established the superiority of the new article over the old, conservative England was exceedingly slow to admit the fact. At the England and Colonial Exhibition in 1851, it received its first great and successful advertisement and from that time on its use has steadily extended.

INGREDIENTS OF CEMENT

The two essential ingredients in the manufacture of Portland cement are lime and clay. In America, the former occurs either as limestone or as marl. While in Ontario all the plants save one employ marl as the source of the lime, it is interesting to note that but sixteen per cent. of the total output of the United States is made from that material.

Marl

The existence of deposits of marl at the bottom of many of our smaller lakes has been explained in various ways. Some there are who contend that marl is composed of the shells of fresh water mollusks. As most marls contain shells more or less perfectly preserved, color is lent to this hypothesis. It is further argued that through erosive and grinding agencies, shells have lost their characteristic forms, and that that portion of all marl which is microscopic and formless has had its origin through the crushing and grinding of shells. Other investigators advance the view that marl has had its beginning through the deposition of calcium carbonate from water containing this salt in solution.

It is a well-known fact in elementary chemistry that water containing carbon dioxide in solution will dissolve a much greater quantity of calcium carbonate than will water in which this gas is not present. It is also well known that when for any reason the gas is expelled from the water, the calcium and magnesium carbonates are deposited as a finely divided powder. It is therefore contended that when water, containing carbon dioxide under pressure and holding in solution a greater quantity of carbonate than it could retain, were it not for the presence of the gas, is discharged from some underground channel, the gas owing to reduced pressure, escapes to the air. The salts are then deposited by precipitation on the sides and bottom of the stream or lake as carbonates of calcium and magnesium, and form the familiar marls of our lakes.

NOT ALWAYS AN ORGANIC PRODUCT

The fact that isolated shells are found perfectly intact at depths of twenty feet in places, would point to the conclusion that shells are not the sole source of marl. For, if that were the case, the number of wholly or partially preserved shells would be much larger at these depths than it actually is. Careful determinations of the quantity of shells and shell fragments present in several samples of marl are reported by Professor C. A. Davis, of the Geological Survey of the State of Michigan, and are included in the publications of the Board of Geological Survey for 1903. Selecting four samples at random, he found that shells and shell fragments comprise on an average little more than a half of one per cent., and in one instance only does it exceed one per cent. The conclusion arrived at in the discussion is that shells are but a minor element in the composition of marl, and that their existence and growth depend on much the same causes as those which produce the marl itself. These causes, recent investigation leads us to believe, are found in the fact that our underground springs contain solution the carbonates of calcium and magnesium, washed from the soil from which the springs are drawn. Differences in opinion now are not so much as to the source of the deposit, as to the cause of its precipitation. That the underground feeders of our lakes are the source of supply would seem to be the theory set forth in The Geology of Canada, 1863, which we quote:

"Although belonging to the present geological period, this marl is not always of recent formation; inasmuch as the beds of it are sometimes overlaid by peat, or by soil supporting a growth of large trees. At other times, however, the marl covers the bottom of shallow lakes or ponds, and is evidently in the process of deposition. It appears to be formed by the waters of springs, highly charged with lime, which is at first held in solution as bicarbonate, but is deposited when these waters come to the air. It is thus similar in its origin to the deposits of calcareous tufa, which occur in many places where such calcareous springs flow over earth, rocks and vegetation instead of falling into lakes or marshes. The presence of carbonate of lime is a necessary condition of the development of shells, and various species of mollusca abound in such waters. These by their remains, which often form a considerable portion of the deposits, give to them the name of 'shell marl,' which is frequently applied. This substance is white and earthly in its aspect and, unless mingled with clay, is a nearly pure carbonate of lime."

Whether the writer of the above held that the water is a surcharged solution of carbonate due to the presence of CO_2, is not altogether clear. Our acceptance of the

theory will depend on whether it can be shown that the percentage of calcium and magnesium carbonates present in our ground waters is above the quantity which can be dissolved in water free from carbonic acid gas. Referring again to Prof. Davis' report above quoted we read:

"According to Treadwell and Reuter's carefully made experiments, water at ordinary temperature and pressure containing no free CO_2, may yet contain permanently 0.38509 grams of calcium bicarbonate, or .238 grams $CaCO_3$ per litre. . . Now the analyses of waters from Michigan show a content of calcium carbonate from .175 to .250 grams per litre. . . . . With this in mind it can easily be seen that the carbonated waters of our springs and marl lakes are generally far below the point of precipitation."

How then is the mineral content of our springs deposited? Clearly, the cause must be looked for elsewhere.

It is a familiar phenomenon in the study of plant life that all chlorophyll-bearing plants, terrestrial or aquatic, absorb carbonic acid gas through the stomata or breathing pores of their leaves. The leaf is the laboratory of the plant; in this laboratory, the gaseous food is assimilated. The carbon and a part of the oxygen composing the carbonic acid gas are retained to build up its own tissues, and the rest of the oxygen rejected to the air. A second chemical reaction is instructive. It illustrates the effect of this free oxygen on the bicarbonates of which calcium bicarbonate, $Ca\,H_2\,(CO_3)_2$ is typical. The following is the equation:

$$Ca\,H_2\,(CO_3)_2+O=CaCO_3+CO_2+O+H_2O$$

In words, it is this: The bicarbonate of calcium in the presence of oxygen becomes the normal carbonate with evolution of carbon dioxide, oxygen and water. The oxygen being nascent, is doubtless free to repeat the process. This then is given as an explanation of the incrustations of carbonate on water plants, which are observable in marl bogs and with which many of us are familiar. The conditions are but two in number; a carbonate-charged water, and the presence of vegetable life. The Michigan Survey report is quoted in conclusion:

"One of the strongest of reasons why the purely chemical theory is not true is lack of marl in some shallows and its presence in others. The lime-bearing water must be distributed evenly to all shallows and should precipitate upon all at an equal depth. This is often contrary to fact, while on the other hand it would be impossible for a local precipitation to be brought about in the presence and only in the presence of water plants producing oxygen."

COMPOSITION OF MARL

An analysis of marl usually reveals the presence of the following ingredients: carbonate of calcium, carbonate of magnesium, ferric oxide, oxide of aluminum, silica, organic matter and anhydrous sulphuric acid.

The calcium carbonate is the essential ingredient in marl, and should of course be a very high percentage of the whole at least ninety per cent. The purest marls run from ninety-five to ninety-seven per cent. of calcium carbonate.

Magnesium carbonate is analogous in its chemical composition and properties to calcium carbonate, but it is characteristic of marl that when the latter is high in the analysis, the magnesium carbonate is low. Further, it has not been shown that this ingredient improves the cement in any way, and if present in large quantities is a positive detriment. The magnesium carbonate should probably not exceed three per cent.

Iron and aluminum, belonging to the same chemical group, are frequently reported together in an analysis. The iron acts as a necessary flux. It will generally be noticed that both ferric oxide and alumina are likely to be light where organic matter is high. Two and a half per cent. is considered the limit for the combined oxides.

The amount of silica in a good marl is small. It ought not to exceed three or four per cent. in the sample. Its presence in a marl interferes with the adjustment of the slurry, and although it is a constituent of clay, it does not make so intimate a mixture with the lime of the marl as does the clay silica.

Sulphur compounds are a positive injury above a two or three per cent. limit, If present in quantities much exceeding this, certain somewhat complex chemical reactions result, which, after the cement has been used, may lead to ultimate disintegration.

Organic matter is more negative in its character and effects than positive. While it increases the bulk of the marl, it really neither adds to nor subtracts from its fitness as an ingredient in cement manufacture, since the organic matter is practically all burned in the process. A greater quantity of course is required to produce the same amount of cement, and hence the cost of manufacture is correspondingly in creased. An examination of analyses shows that marls free from organic matter are likely also to be free from injurious ingredients. Elsewhere are given the results of analyses of samples of the marls from which our Ontario Portland cements are made.

MARL DEPOSITS IN ONTARIO

In the descriptions of plants, to follow, reference will be made to Ontario marl deposits which have been or are soon to be worked. There are many other areas where, for various reasons, nothing in the way of development has been undertaken. Among these reasons may be mentioned smallness of deposit, remoteness from railways or other shipping facilities, and the possible over-production which of late years has been feared by the more conservative observer in Ontario. In any case, it would appear as if there is little danger of a dearth of this material in the Province for many years to come. In 1902, the Geological Survey of Canada published a little brochure giving a list of the more important Canadian marl deposits. The compiling was done by Dr. R. W. Ells, and no doubt was tolerably correct as to the areas known up to that time. The following list is selected mainly from the pamphlet referred to, and gives a fairly good idea of the number and some detail as to the extent of these deposits. Those which have been worked will be dealt with similarly later on. Many deposits of marl are also enumerated in the Reports of the Bureau of Mines—particularly Part II of the Thirteenth Report, "The Limestones of Ontario."

In the township of Storrington, Frontenac county, about ten miles north of Kingston, there is a large deposit of marl occupying the bottom of Loughborough lake, more especially the southeastern portion. The depth of water is not great, and although the deposit is believed to be very large, little concerning its depth seems to be known. Marl is also found in the bottoms of many of the lakes between this place and White lake in Olden township. These deposits are convenient to both the Rideau canal and the Kingston and Pembroke Railway.

Deposits are said to occur near the city of Belleville, Hastings county, but no data regarding their size are given.

In the township of Yonge, Leeds county, near the village of Athens, there are several beds of marl which have never been exploited. One of these is on lot 13, range VIII, and is said to occur over an area of at least twenty-five acres, with an ascertained depth of seven to fifteen feet. The material is also reported as occurring on lots 7, 8 and 9, range IX, at the bottom of Mud lake, and possibly at other points in the vicinity. In the township of Elmsley in the same county, it is found underlying portions of Bass lake, of a thickness from three to four feet, but the exact extent of the deposit is not known.

Nature has been very generous to Renfrew county in the matter of marl deposits. In the township of Wilberforce, near the Bonnechére river, and about three miles from the line of the Canadian Pacific railway, between Douglas and Eganville, is Mink lake. This lake has an area of one thousand acres, and marl is believed to cover most of the bed of the lake, being visible in many places. The depth is known to be nine feet in places, and no doubt much exceeds this in others. The lake could be easily drained. In the towship of McNab, the lower end of White lake shows a large area of marl, extending over some seven hundred acres. The depth is from five to seven

feet, and the difficulties in the way of draining are inconsiderable. The distance from Arnprior and railway communication will be about eight miles. In the township of Ross several deposits are known to occur in a chain of lakes which extend southeast from Muskrat lake, near Cobden village, and which are believed to form the prehistoric valley of the Ottawa river, extending from Pembroke eastward. At Green lake, on lot 13, range IV, the marl is found in one place with an exposed area of five acres and a depth of from five to twelve feet. On lot 15, range II, in another small lake, considerable deposits are found, especially near the outlet, and it is supposed the same material underlies the water. Other lakes of the chain also have deposits, the extent of which has not been accurately determined. In the township of Westmeath, on lots nine and ten east from B, shell marl on the shores of a small lake is known to occur, but to what extent is uncertain.

In Emerald lake, Nipissing district, near lake Temiskaming, there is a deposit of marl which is thought to be of considerable extent. With the opening of the adjacent territory, this material may have an early commercial value.

"Among other places where the material is found in this Province, but where the extent of the deposits has not been determined, may be mentioned lot 13, range IV, township of Lavant, Lanark county, six acres in area, and seven feet deep; Chalk Lake, lots 1 and 2, range I., and lot 1, range II., township of Reach, Ontario county, a lake of seventy-five acres with a marl bottom, the thickness of which is considerable, but is not definitely stated. In this list may be included White lake, lots 18 and 19, range IX, Huntingdon, Hastings county, the deposit extending out under the waters of the lake and found to be thirty feet thick in places; and the Eramosa branch of Green river, Eramosa township, Wellington county, where the deposit is at least three feet in thickness, with a covering of three feet of peat."

In Artemesia township, Grey county, there is a seven-foot depth, covering an area of at least twelve acres. At the lower northwest end of Clear lake, in the township of Sebastopol, Renfrew county, there is a large quantity of marl. This deposit, and several others in adjacent lakes will probably some time prove an attraction for Canadian capital. On the shore of Hemlock or Mackay lake, at New Edinburgh, Ottawa, marl has long been known to exist, extending over one hundred acres or more, with a depth of at least five feet. The deposit is, however, largely covered with soil and forest growth, but has been locally used to some extent in the manufacture of white brick. In Prescott county, in the vicinity of the Ottawa river, on lot 18, range IV, West Hawkesbury, there is an area, the extent of which has not been definitely determined, but it is known to cover from five to ten acres, and to be three feet in depth at least. The marl is covered with four or five feet of peat.

THE VALUE OF A MARL BED

Anything pretending to a discussion of marl deposits would certainly lack completeness without some reference to their latent possibilities. To say that an area of one hundred acres has a deposit of marl running to an average depth of fifteen feet is to give to the ordinary person almost no conception of the potentialities of such a deposit. There are all sorts of conditions which affect the value of a marl proposition, among which will be the water percentage, and the calcium carbonate content, as revealed by a chemical analysis. In order to make an estimate, these two and certain other unknown elements entering into our problem must be assumed.

A barrel of cement contains three hundred and fifty pounds, sixty-three per cent. of which, let us say, is lime. Sixty-three per cent. of three hundred and fifty is two hundred and twenty and a half pounds, which quantity of lime is supplied almost altogether by the marl. Let us assume that the marl in question has a carbonate content of eighty per cent. and contains on dredging say sixty per cent. of water. From this, it follows that one hundred pounds of fresh marl will give forty pounds of dry material, which in turn will give eighty per cent. of forty, or thirty-two pounds of pure calcium carbonate. Now, of calcium carbonate, but fifty-six per cent. is lime. This means that of our hundred pounds of dredged material, only eighteen lb. become

a constitutent of the finished product. Since a barrel of cement requires two hundred and twenty and a half pounds of lime, it is clear that for its manufacture nearly thirteen hundred pounds of wet marl will be required. Again, a cubic yard of our dredged marl will weigh about two thousand five hundred pounds, and so we find that one barrel of cement will be produced from fifty-two hundredths of a cubic yard of wet marl. A plant of three hundred barrels per day capacity would consume one hundred and fifty-six cubic yards per day, or forty-six thousand eight hundred cubic yards per year of three hundred working days.

But, returning to our deposit, we find that one hundred acres of a depth of fifteen feet will contain two million, four hundred and twenty thousand cubic yards of marl, or a sufficient supply at the assumed rate of consumption to last for fifty years.

Manufacturers state that from three-tenths to five-tenths of a cubic yard of marl are necessary to produce a barrel of cement. It will be noticed that the greater of these limits is slightly below that of our computations, the data for which were of course purely hypothetical.

Clays

The silica and alumina required in the manufacture of Portland cement are supplied by the clay or shale, as the case may be. Pure clay may be designated by the formula $Al_2O_3.2SiO_2+2H_2O$, and is therefore a silicate of aluminium. It should be remembered, however, that the silica present exists in the combined or soluble form, and not as granules of sand. Any clay, therefore, that is gritty to the touch or in the teeth, if chewed, is objectionable, for the reason that it probably contains uncombined silica. This in the kiln is very refractory, requiring for its combination with the lime a much more intense heat than does the combined silica of the formula. Cement could, of course, be manufactured by using sand as the source of the silica, were it thought prudent to reduce it by grinding to a state of sufficient fineness, and to employ the greater heat which would be rendered necessary.

The best clays for the manufacture of Portland cement have a greasy, unctuous feel, and are quite smooth to the touch. "Clays which stain the fingers should be avoided as being either too much impregnated with iron compounds or containing a large proportion of organic or other impurities." Clays also containing much calcium carbonate should be avoided, as the percentage of this ingredient is liable to great fluctuation, and its presence in the clay complicates the proportioning of the ingredients very much. A simple test for clay is the application of hot dilute acid. If there is much effervescence on the addition of the acid, the material is objectionable because of the presence of carbonates.

Analyses of an available clay should in all cases be made in order to determine the composition and its uniformity. The same ingredients as in marl may be looked for, but of course in widely different proportions. Preferably the ferric oxide and the alumina should in the analysis be separated. In general, a clay that contains not less than two parts of silica to one of combined iron and alumina is preferred. This in a good sample will be between forty and sixty per cent. Calcium carbonate as stated above, is objectionable, not because of its composition, but because of the difficulty in correctly proportioning the mixture. Oxide of magnesia should not exceed three per cent. Manufacturers tell us that magnesia refuses to unite with the clay at the temperature with which the latter and the lime combine. In consequence, the magnesia remains in the finished cement as the oxide. Like free lime, this expands and disintegrates on the addition of water and in a mortar is likely to cause trouble. Ten per cent. of lime, and two per cent of sulphuric acid, will be the maxima for a good clay.

The following analysis is of a clay that would answer very well as an ingredient of cement:

	Per cent.
SiO_2	61.06
Al_2O_3	18.10
Fe_2O_3	6.65
CaO	1.25
MgO	.53
SO_3	1.05
Loss on ignition (CO_2 and water)	9.20

It will be noticed that the silica is considerably in excess of twice the cambin oxides of iron and alumina, that the lime is nearly down to the one per cent. limi and that both magnesia and anhydrous sulphuric acid are low. The organic matt and water, being expelled in the process of calcination, do not enter into the reactio in any way, and of course are equivalent to so much inert and useless matter, affectir chiefly the cost of transportation of the raw material. It has been stated els where that a high percentage of alumina will quicken the setting of the finishe cement. In the above analysis the alumina is slightly high, ten or twelve per cen giving the best satisfaction, as a general rule. This defect, however, can be correct by the addition of gypsum in the usual way.

In general, the process of manufacture consists first in mixing intimately the tv ingredients in a finely divided condition; secondly, in subjecting the mixture th obtained to a heat sufficiently intense to expel the carbon dioxide, and to form clinker but not to vitrify; and thirdly, in grinding the clinker when cooled to impalpable powder. The details of the process vary with every plant, but the resul sought are identical in all.

Chemical Composition of Cement

An elaborate series of experiments, synthetic and analytic, conducted by D Newberry and others has led to the conclusion that Portland cement is a mixtu of silicates and aluminates of lime, chief of which are the tri-calcium silica ($3CaO.SiO_2$) and the di-calcium aluminate ($2CaO.Al_2O_3$). Moreover, Newber showed that if lime (CaO) and silica ($SioO_2$) in the proportions indicated by t weights of combination in the first formula, be thoroughly mixed and subjected sufficient heat, a product showing the hardening properties of Portland cement w result. And further, if lime and alumina (Al_2O_3) be similarly treated, the prod will show the phenomenon of setting peculiar to Portland cement. His inference that these two compounds may and do exist in various proportions in Portland ceme and that there is no fixed or necessary ratio between them. In a cement analysi iron oxide and alumina are usually reported together, and indeed ferric oxide supposed to be analogous in its hydraulic effect to alumina. Hence it follows th an analysis high in alumina and iron oxide usually denotes quick setting properti while a cement high in silica is likely to develop great ultimate hardness. We s "likely," since rapid setting may be due to insufficient mixing or to underburnin while slow setting in cement may be due to overburning.

By a simple calculation involving the atomic weights of the elements concerne it can be shown that the lime and the silica are in the ratio of 2.8 to 1 by weight the silicate; and that the lime and alumina are in the ratio of 1.1 to 1 in t aluminate. From this Newberry deduced his "hydraulic index" or ratio between t basic element on the one hand, ad the acid elements on the other. It is usually stat as follows: multiply the percentage of silica by 2.8 and the percentage of alumi by 1.1. The sum will be the maximum percentage of lime to be looked for in t cement.

The following analysis of a cement is taken at random from the directory American Cement Industries for 1904, p. 38.

Lime	62.30
Magnesia	1.20
Silica	21.30
Alumina	6.95
Oxide of Iron	2.00
Sulphuric Acid	0.98
Loss on Ignition, Alkalies	4.52

Now $21.30 + 2.8 + 6.95 \times 1.1 = 67.28$. This is seen at once to exceed the per-
tage of lime (62.30) as given in the report. Without considering the similarity
veen magnesia and lime, we find that the acid elements present are capable of
abining with 67.28 units of weight of lime. That there are only 62.30 units of
e present according to the analysis is due partly to the fact that the formula
resents the maximum quantity of lime that will combine with the silica and
mina, and partly to the fact that the manufacturer choses to attempt less than
s maximum rather than run the risk of overliming his cement. There are other
rces of error. The ash remaining from the process of burning passes into the
ent. This is largely silica and alumina, and of course operates to give the im-
ssion that the cement is overclayed. Then too, gypsum is always added to lengthen
time of setting, and if this be reported as lime and sulphur trioxide, it will
rease somewhat the percentage of lime.

The pernicious ingredient in cement is free lime. If clay be in excess its effect is
positive, since clay in cement is inert matter. Free lime on the other hand will
duce dire results. In time through the action of atmospheric moisture or of water
submerged, the lime slacks and the mortar or concrete of which it is a constituent
integrates and falls to pieces. Experience, however, shows that an excess of free
ie reaching one and a half per cent. is not likely to manifest any destructive ten-
ncies. Still, manufacturers preferring to take no risks of overliming, usually allow
ir product to contain a small excesss of clay or sand.

Now it must be borne in mind that a chemical analysis of cement may not reveal
true character as a material for construction. Ordinary analyses do not dis-
iguish between free and combined lime. A cement may be properly mixed, but
properly burned, in which case a chemical analysis would fail to detect the defect.
e past test to be described later, would be a much more reliable indication of the
lue of the cement.

COST OF CEMENT PLANT

The cost of a modern plant manufacturing Portland cement from marl and clay
ay be put at fifty thousand dollars per rotary kiln installed. This estimate includes
e cost of dredging and transporting the raw materials, that of wash mills, grinders,
rage tanks, rotary kilns, coolers, finished grinder and stock packing houses.
ie equipment for power generation is included, and also the entire cost of erecting
itable buildings, everything to be modern and first class. Assuming that the out-
it of each rotary is one hundred barrels per day, we have the investment in plant
five hundred dollars for each barrel of the rated daily capacity. Doubtless by the
stallation of some form of continuous upright masonry kiln, the cost might be
nsiderably reduced, yet the wage account where such methods are employed is
ways much higher per unit of output, the amount of manual labor necessitated being
nsiderably greater.

Experience in Ontario and the United States has proved, and without a doubt
ill continue to demonstrate that the higher profits in the cement industry are realized
those plants having a large capacity. It is the smaller manufacturers in Ontario
-day who find it most difficult to pay dividends in the present condition of the
ment market.

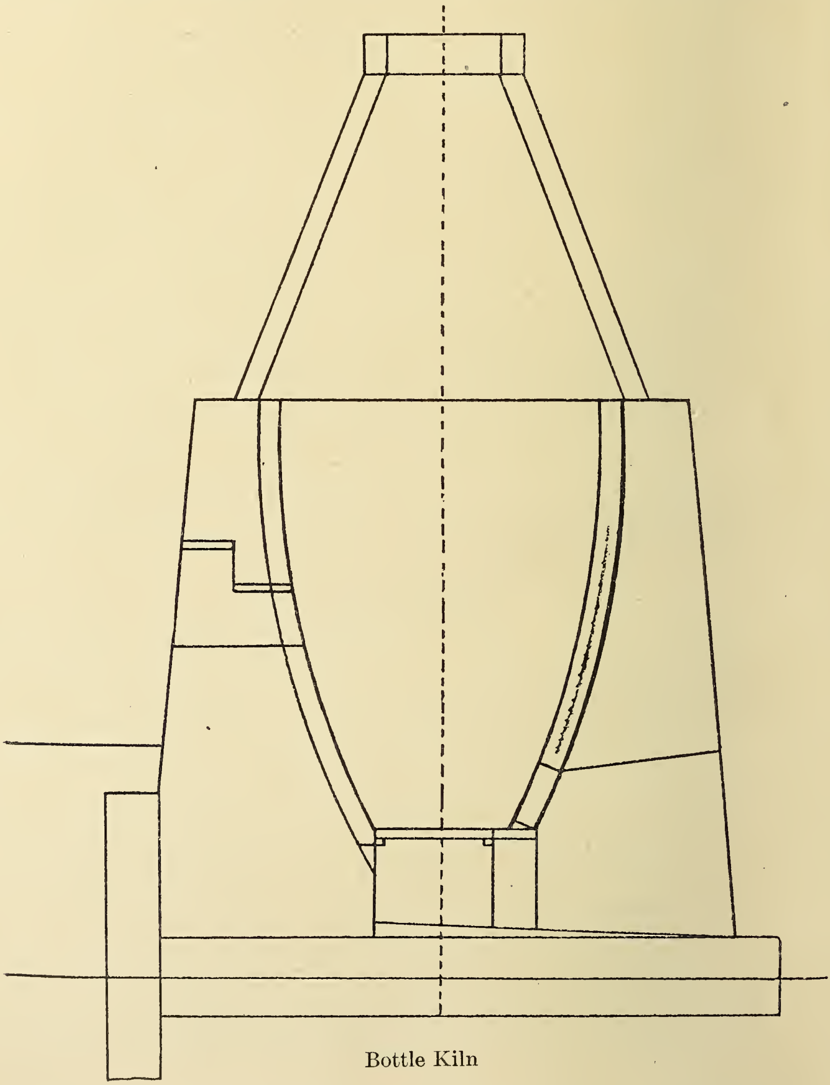
APPLIANCES USED IN MAKING CEMENT

Wash Mills

Washmills are usually built with concrete sides and bottom, and are circular,
exagonal or octagonal in form. The diameter is from eighteen to twenty feet, and
e depth is about eight feet. There is an upright centre shaft having horizontal
ms or spokes, which carry "drags," usually three in number. Washmills are em-
oyed for the preliminary mixing.

Intermittent Kilns

Of intermittent kilns, there are two types, the "bottle" kiln and the Batchelor. The former as the name would indicate, is in vertical section, shaped somewhat like a bottle. The outer structure is built of brick or stone, and the lining, on account of the excessive heat to which it is exposed, is of fine clay. The fire is started on the



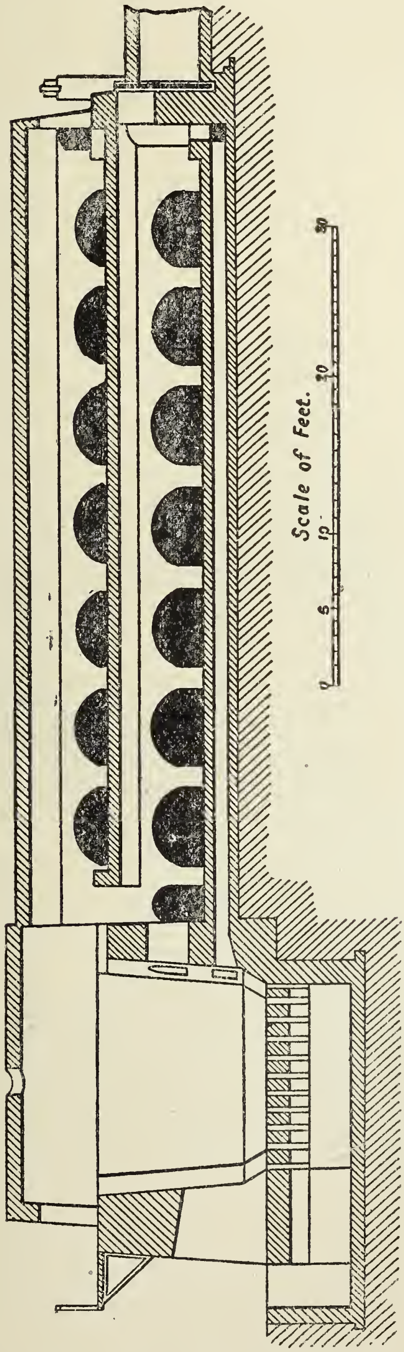
Bottle Kiln

grating below and when well under way, alternate layers of coke and dried slurry are laid in. When the burning is completed, and the clinker allowed to cool, it is "drawn." The processes of loading, firing and sorting the clinker all require considerable skill, and of a kind, too, wholly born of experience.

The Batchelor Kiln

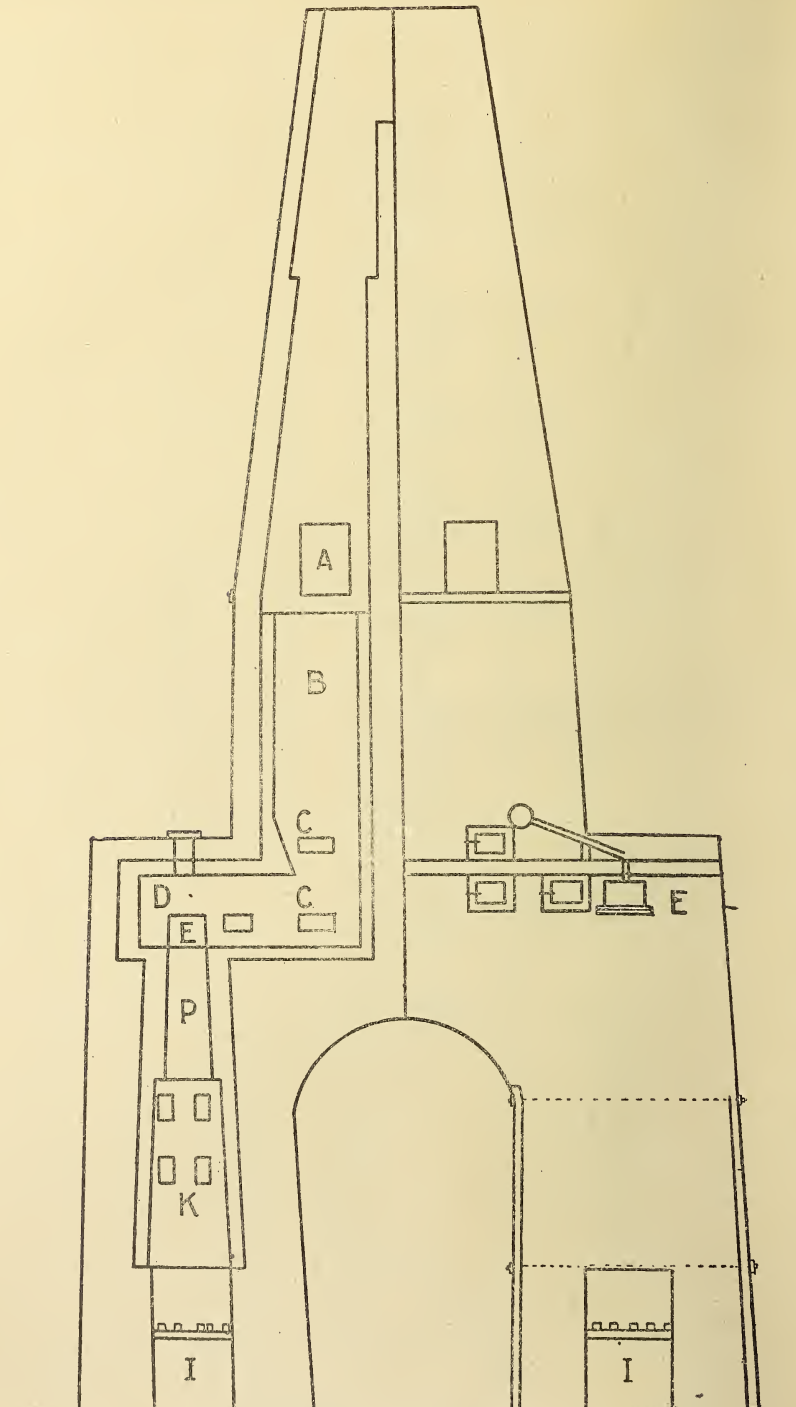
No attempt to utilize the waste heat from the firing chamber is made in the bottle kiln. This in done in the Batchelor kiln. If we conceive a long covered archway with a cement floor, annexed to the bottle kiln in such a way that the escaping

gases are obliged to pass through it on their way to the stack, we have the principle of the Batchelor kiln. The slurry is pumped over this floor to a depth of a few inches,



Batchelor Kiln. The kiln proper is the chamber on the left. The two slurry drying floors are shown to the right, one along the other. (Butler's "Portland Cement.")

and while one charge is being clinkered in the furnace of the kiln, a second is being dried on the archway floor. The Batchelor kilns are usually constructed in batteries of six, having a single stack to which all flues lead.



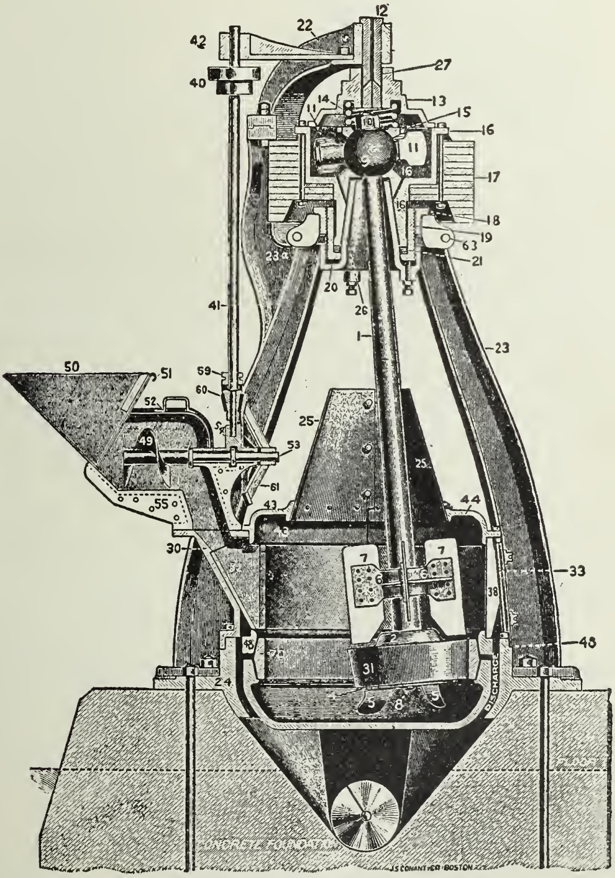
Dietsch Kiln. Half elevation, half section. A.—Loading port. B.—Heating chamber. E.—Full charging port. P.—Burning chamber. K.—Cooling chamber,

The Dietsch Kiln

The Dietsch kiln is one of the continuous types. The "forewarmer" is really the lower part of the stack, there being here a shelf or ledge which prevents the mass of slurry bricks above from falling down. The coal is charged into the furnace from the floor beneath that from which the dried slurry is charged. The "drawing" is done from below, every four or six hours, and to replace the material thus drawn, a fresh supply is dragged by hand from the ledge above referred to. The kiln is provided with suitable "ports" or "eyes" for firing and loosening the bricks when "hung up."

The Griffin Mill

This mill is used at some factories for grinding the finished product. It consists of a steel ring against the inside surface of which a heavy steel roll is made to revolve. This roll, by centrifugal force, exerts a pressure against the steel ring. Screens are



Griffin Mill. (Butler's "Portland Cement.")

provided so that the clinker when sufficiently ground can pass through, the coarser particles, however, falling back again to the mill. The heavy roll above referred to is attached to an upright pendulum-like shaft.

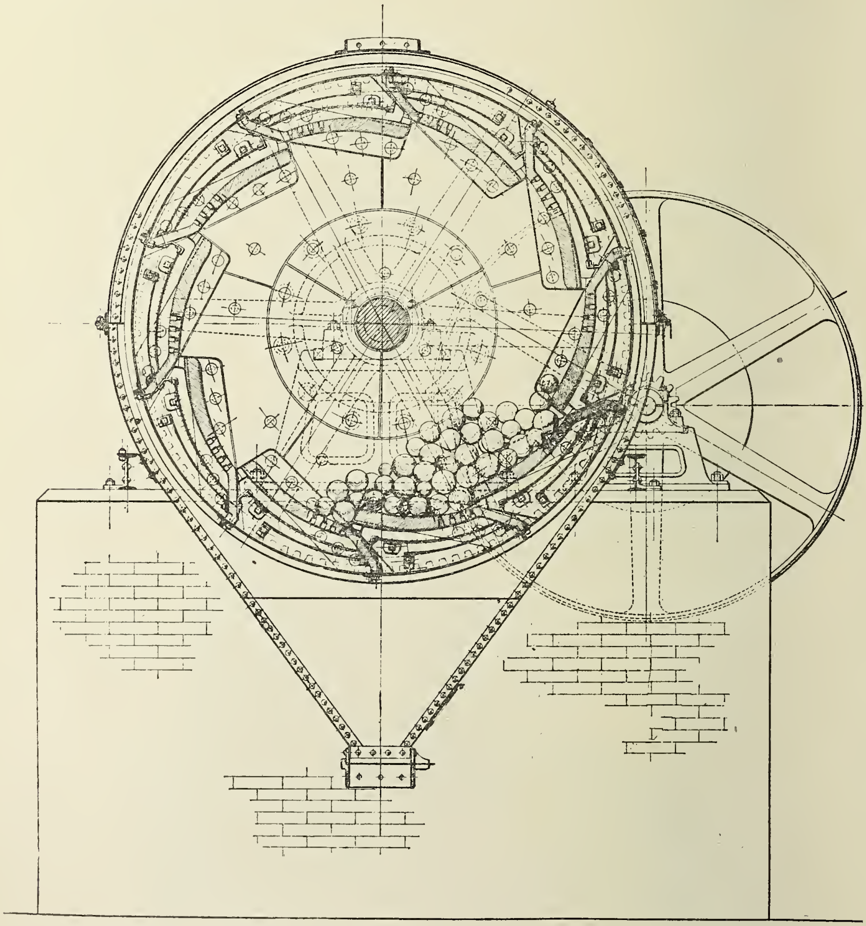
The Alborg Kiln

The general scheme in the Alberg kiln is similar to that of the Dietsch kiln. There is, however, no ledge in the Alborg kiln. The narrowest portion of the kiln, or

"throat" occurs where the coal is charged into the kiln. Above this, the slurry bricks part with their moisture, and below it, the firing takes place. Below the firing zone the cooling occurs. No attempt is made to utilize the waste heat.

The Rotary Kiln

The rotary kiln is simply a huge revolving cylinder of boiler steel set slightly on an incline. The lower end is closed by a "hood" mounted on wheels, so that it can be rolled back at pleasure. Through this hood passes the pipe which admits the fuel, usually ground coal. The fluid slurry is pumped in at the upper end. Rotary kilns have a capacity of about one hundred barrels per day, depending on the kind of slurry and the length of the kiln.

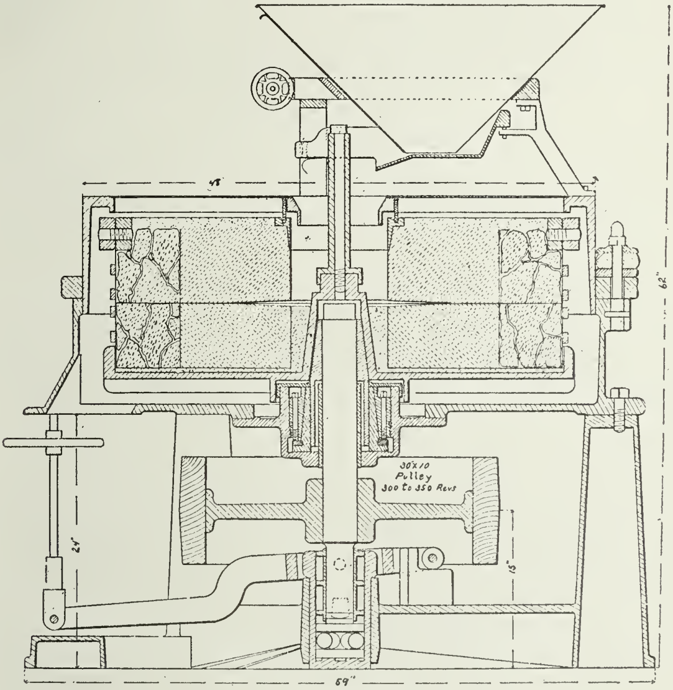


Gates Ball Mill. Cross-section showing shields and screens. (Allis-Chalmers Co.)

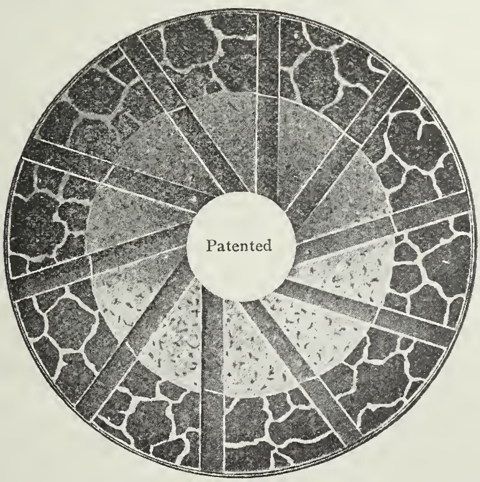
Ball Mills

Ball mills are employed to do the coarser grinding of the clinker only. They are in the form of short cylinders revolving on their axes and containing a number of large steel balls. The circumference of the mill is provided with overlapping "wearing plates" and two sizes of screens. The material as it is reduced to sufficient fineness passes through holes in the plates and through the meshes in the sieves, all particles

not sufficiently reduced to pass the finer of the sieves being returned to the mill in the process of revolving. The finer particles pass to a hopper below. The clinker is fed in through one of the trunnions of the mill.



Emery Mill; cross section. (The Sturtevant Co.)



Rock Emery Millstone. (The Sturtevant Co.)

Sturtevant Emery Stones

These mills are used both for wet and dry grinding. They consist of two built-up stones. The parts are of natural emery rock, and are mounted as are the well-known buhr stones at one time very common in flour mills. Emery grinding stones are mounted vertically as well as horizontally.

Tube Mills

Tube mills are cylindrical in form, usually about five by twenty feet. They are employed in both raw and final grinding. A tube mill must of course be lined with some resisting material, usually silex stone, since it is partially filled with flint pebbles, which accomplish the grinding of the clinker or slurry, as the case may be. As in the ball mills, the feed is through one of the trunnions of the mill.

The Gates Crushers

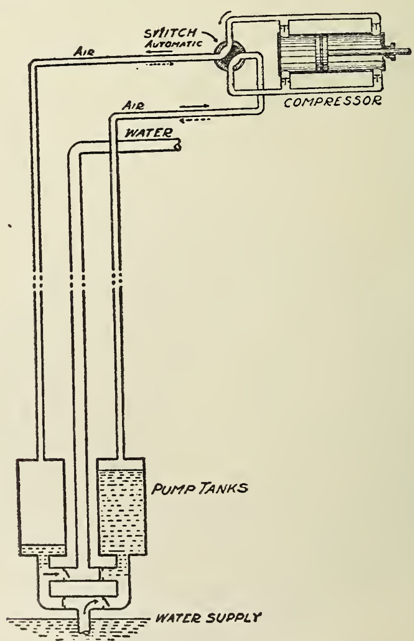
The Gates rock and ore breaker is of the gyratory type, and is capable of crushing from 75 to 125 tons per hour, depending on the size of the machine employed. The size to which the rock can be reduced can be controlled at will within certain limits. The axis of the mill is vertical.

The Mosser Tower Cooler

The Mosser cooler consists of a circular tank eight feet in diameter, and thirty-two feet high, fitted with internal blast pipes and cones. The hot clinker is elevated outside and dumped in at the top. The tank is supposed to be kept practically full of clinker, which is withdrawn from the bottom as fast as it is supplied at the top A Mosser cooler will handle the output of four rotary kilns.

The Harris Pneumatic System

This system is employed for pumping all kinds of fluids including wet marl and slurry. The accompanying figure is diagrammatic, but serves to illustrate the method. The operation is as follows:



The Harris System of Marl Pumping. (Pneumatic Engineering Co.)

"Suppose the compressor to be in operation and the switch set as in the figure. The air will be drawn out of the right tank and forced into the left one, and in so doing will draw the fluid into the former and force it out of the latter. The charge of air in the system is so adjusted that when one tank is emptied the other is filled, and at that moment the switch will be automatically thrown reversing the pipe connections and thereby reversing the action in the tanks."

CEMENT PLANTS OF ONTARIO

Following is a description of the various cement-making plants in Ontario, including those in process of construction, as well as those actually in operation, as seen by the writer at the close of 1904 and the beginning of 1905.

The Belleville Portland Cement Company

President	A. Ansley.
Vice-Presidents	John McGowan, M. P. Miller Lash.
Manager and Sec.-Treas.	J. W. McNab, Belleville.
Works	Point Ann, Ont.
Authorized capital	$2,500,000.

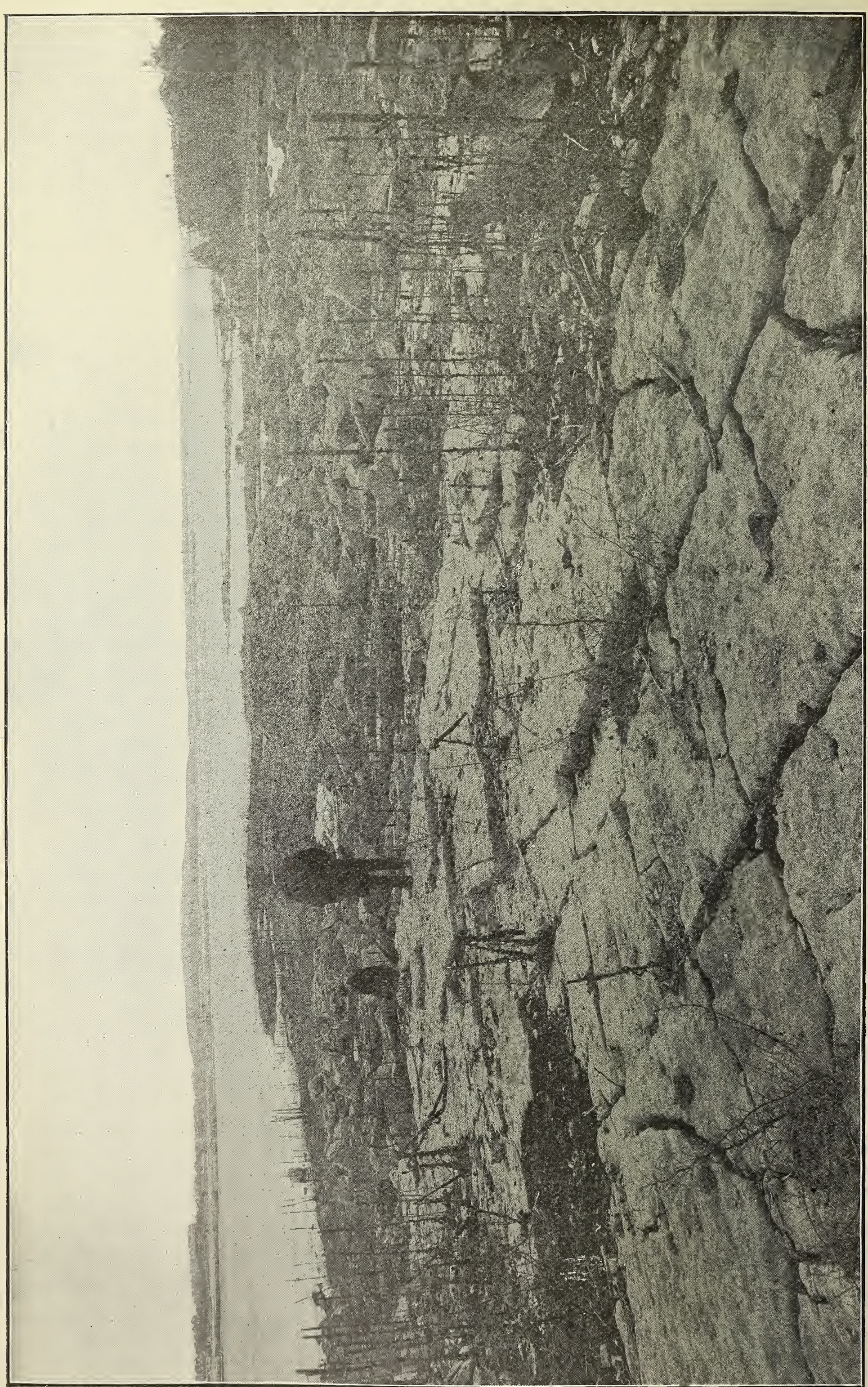
That this company will begin the manufacture of cement with a singularly valuable asset in the shape of natural opportunities is at once manifest. These natural opportunities are, first, almost inexhaustible deposits of raw materials conveniently situated; secondly, a good harbour, and thirdly, first-class shipping facilities by water.

The Belleville Portland Cement Company, unlike any of its competitors in Ontario, proposes to use limestone and clay as its raw materials, and for this purpose is rapidly carrying to completion extensive works at the Point Ann peninsula, on the Bay of Quinte, some four miles east of the city of Belleville. The works are connected with the Grand Trunk Company's line at Belleville station by a standard gauge track, for the construction and operation of which a railway charter was obtained. The limestone is exposed in most places and comprises an area of 386 acres. The depth, ascertained by borings, is known to be upwards of thirty feet. The clay is found on the same property, part of it indeed but a few hundred feet from the plant. Other deposits are on the line of the company's railway, so that delivery without freight charges will be assured. The total clay area is in the neighborhood of 40 acres, and runs to a depth of sixteen feet in places.

The limestone will be brought to the works by narrow gauge tracks, and will receive its preliminary treatment in two Gates gyratory stone crushers, each having a capacity of forty tons per hour. Five Sturtevant crushers of the coffee-mill style will next take charge of the stone, reducing it approximately to a quarter-inch mesh.

The clay also will be brought from the beds by narrow gauge cars, and will be first passed through a rotary drier. This consists essentially of a cylinder of boiler plate sixty feet long, five feet in diameter, and partitioned longitudinally by plates which divide its cross-section into quadrants. It is made to revolve on its axis, which is placed in a position nearly horizontal. A furnace is built at the lower end in such a way that the waste gases therefrom must pass through the cylinder on their way to the stack with which the upper end is connected. The clay is fed into this upper end through the rotary motion of the cylinder, and is finally discharged from the lower end, having come in contact with the hot furnace gases in its progress through. Ordinary soft coal will be the fuel employed at the Belleville plant. The crushed rock and clay will then be mixed in proper proportions by specially constructed weighing machines, after which they will be together passed through a second drier identical with the first. The object of this is to still further reduce the moisture present in the clay, and to remove any surface or other water adhering to the stone.

Screw conveyors will carry the material to a storage bin in the mill room of five hundred tons capacity. As desired, it will be admitted to Griffin mills preparatory to being still further reduced in the tube mills. The Griffin mill to be employed is a modification of the well-known American Griffin mill, is made by Mr. A. D. Griffin of Galt, and is known commercially as the "Senator."



The Belleville Portland Cement Co. A corner of the limestone deposits.

Two tube mills will complete the raw grinding, it being estimated that these will have a combined capacity equal to that part of the plant previously described.

The ground limestone and clay, at this stage reduced to a fine powder and intimately mixed, will be transferred by screw conveyor to the kiln room where the process of clinkering is to be carried out. This room is supplied at present with four rotary kilns, each sixty feet long and seven feet in diameter. They are set on a slight incline, and the material to be calcined will be fed in at the upper end, and the ground coal for fuel at the lower. As in the process of drying, the material, now white-hot clinker, will be discharged at the lower end of the kiln. Here it will be received into rotary coolers—one for each kiln. These coolers are analogous in construction to the rotary driers, and are similarly longitudinally divided, but are not lined in any way.

A feature of this plant is the method employed of utilizing the heat of the combustion gases from the rotary kilns. Adjacent to the upper end of each kiln is installed a 450-h. p. Babcock and Wilcox tubular boiler. The gases from the kiln prior to being discharged into the open air will pass down and through a brick arch and underneath the boiler. These gases will be at an estimated temperature of 2,000° F., and their surcharge of heat will be utilized to make steam for the development of the power for operating the plant. When necessary, the heating of these boilers may be supplemented by stoking. The designers estimate that seventy per cent. of the power required will be generated in this way. When it is remembered that the mere act of converting one pound of water at boiling temperature into steam at the same temperature requires 536 times as much heat as to raise a pound of water through one degree, it will be understood that the waste gases in any system of dry burning will be at a much higher temperature at exit than where fluid slurry is used. A recognition of this principle led to this method of using what would otherwise have been a great waste of energy.

Another exemplification of economy in design is the use of the heated air from the rotary coolers to produce the combustion of the ground coal in the rotary kilns. This air heated to a moderately high temperature through coming in contact with the white-hot clinker, will be drawn into the kilns, and this heat will be of assistance in producing the intense temperature required in the process of clinkering.

The clinker, after being discharged from the coolers, is conveyed to the grinding room, the final and raw grinding being accomplished under the same roof. The ground cement wlil be stored in a stock house 100 feet wide and 500 feet long, convenient for shipping either by boat or rail. Two docks, one for the unloading of coal, and the other for the shipping of the cement, have been constructed and afford a depth of seventeen feet of water.

The power equipment consists of a 600-h.p. Corliss tandem compound engine, made by the John Inglis Company, direct connected with an eight-inch line-shaft. This drives all the machinery in the mill room. In addition, there is a 400- k. w Westinghouse steam turbine direct connected to a generator which operates everything else. An emergency engine of 150-h. p. is also provided. The whole steam plant will be condensing, the water being supplied by centrifugal pumps. Individual motors are largely employed throughout the works. The management look forward to the utilization at some future time of the power of the Trent river. This power could be developed and transmitted electrically possibly at a less cost than steam at the works.

A fuel building has been erected. Griffin mills will be employed to grind the coal. The initial capacity will be one thousand barrels per day, but provision has been made for its ultimate increase to two thousand five hundred barrels by the addition of more machinery.

The Canadian Portland Cement Company, Limited

President .... E. Walter Rathbun, Deseronto.
Managing Director .... F. G. B. Allan, Deseronto.
Works .... Marlbank and Strathcona.
Brand ...."Star."
Capitalization .... $1,500,000.

Messrs. Rathbun & Co. were among the first to attempt the manufacture of Portland cement in Canada. Their first plant at Napanee Mills, now Strathcona, on the Bay of Quinte railway, manufactured natural cement from 1880 to 1897, the material being found in the Trenton limestone of that locality. The company's first experiments in the manufacture of Portland cement from marl were made about 1886, and were continued for five years at great expense before any very encouraging results were obtained. As a commercial enterprise in Ontario, this industry therefore really dates from 1891. At that time, the Rathbun Company had erected at Napanee Mills, three upright masonry kilns for the burning of Portland cement, the marl being obtained from Marlbank station, thirty miles from the plant. The clinker in those days was broken in jaw crushers and "edge runners," and received its final treatment in the buhr stones. These methods have been completely superseded in Ontario by others which have proven more economical and more efficient, but it must be granted that the well-nigh perfect processes now in vogue are the evolution of the defective methods of the pioneers in the industry, to whom for energy and perseverance, we of to-day owe a debt of gratitude.

A company organized under he title of the English Portland Cement Company, began the manufacture of Portland cement at Marlbank about 1891. In 1898 the Beaver Cement Company of Montreal, with capital furnished principally by Philadelphia people, took over this plant and operated it until 1900, when the Rathbun Company's interests were amalgamated with the Beaver Cement Company's, the result being the Canadian Portland Cement Company.

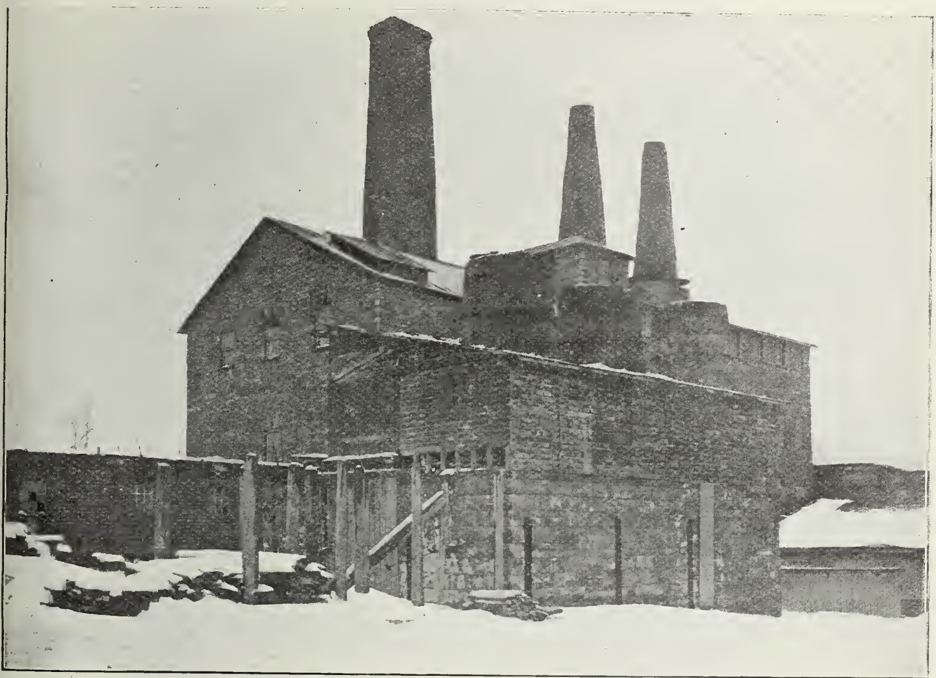
THE STRATHCONA PLANT

The Strathcona plant during the past year did nothing except grind a part of the clinker produced at the Marlbank works, and the probability is that its mixing and burning appliances will not again be called into requisition. A brief description of these may be read with interest.

The clay and marl were mixed in a rotary washmill thirty feet in diameter, ground in a tube mill and pumped to the storage vat twenty feet in diameter and eight feet deep, where the slurry was tested and adjusted. Part of this was then dried in three rotary Cummer driers, from which it was conveyed to the pug-mill. Here the dried slurry was mixed with sufficient wet slurry to produce a batter that could be made into bricks in the brick machine. These bricks were loaded on to cars provided with racks and pallets, and run into the drying tunnels. These tunnels are one hundred feet long and hot air was continually being drawn through them. The process of drying occupied two or three days, at the end of which time the cars were taken from the other end of the tunnels, and the bricks conveyed to the kilns. There are two continuous Dietsch kilns, two continuous Alborgs, and two intermittent bottle kilns. The fuel used for those of the first and second types was soft coal, but for the latter, coke exclusively was employed. The cement made in these bottle kilns was usually of excellent quality, and was of a peculiar bluish gray color, which formerly was generally regarded as superior and is still preferred by some. These kilns had a capacity of one hundred and twenty-five barrels each per burning, which was of three or four days' duration.

The grinding is now done in two ball and three tube mills installed in 1896. Power for this purpose is transmitted from the steam plant to the grinding building,

a distance of three hundred feet, by rope drive. The company has its own fire-fighting appliances, and maintains a laboratory where daily physical tests on the cement are made. The brand here as at Marlbank is "Star," but a silica cement is also manufactured. This is made by adding to the cement in the process of grinding a quantity of quartz sand, which is also subjected to abrasion in the tube mills The output at Strathcona is four hundred barrels per day.



The Canadian Portland Cement Co., Strathcona. The rectangular stack to the left is that of two Dietsch kilns. The two to the right belong to two Alborg kilns. The three low kilns in the foreground are of the intermittent "bottle" type.

THE MARLBANK PLANT

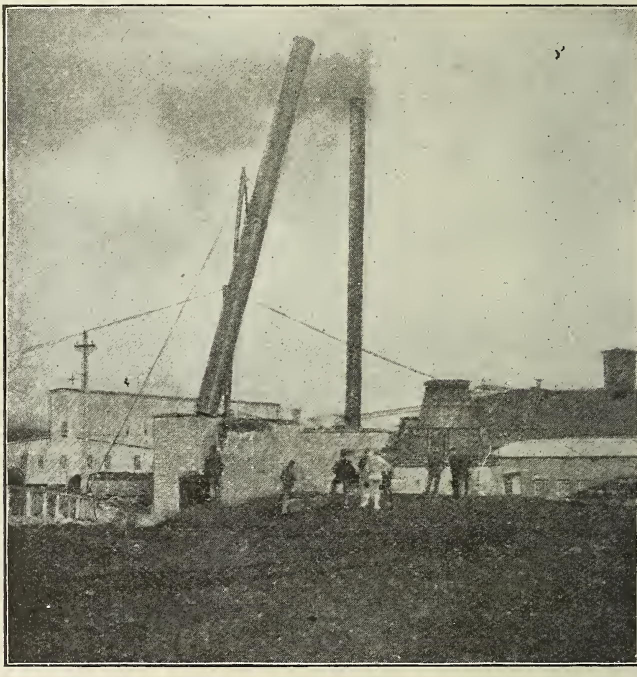
This modern plant is situated at the village of Marlbank, on the Bay of Quinte railway, twenty-five miles north of Strathcona. At present, its mixing and burning capacity is sufficient to keep employed the grinding plants at both Marlbank and Strathcona, the clinker being shipped from the former by rail.

Marl and clay are the raw materials and are at present obtained from Dry lake, adjacent to the works, the water having been lowered for the purpose. From ten to twenty feet of marl is found beneath the water, and below this in turn is the clay varying in depth from ten to twenty feet. A locomotive and train of cars is constantly employed in hauling the materials from the movable dredge to the works. In addition the company has two other very convenient sources of materials, namely, Lime lake and White lake, the latter comprising some eight hundred acres. It is safe to say that there is here sufficient material to last several hundreds of years at the present rate of consumption.

The marl and clay are dumped into the washmills, of which there are three—one for the clay and two for the marl. The ingredients work through gratings into chambers, from which they are pumped into measuring cylinders. Of these there are two, one for the clay and one for the marl. These empty into a common tank, from

which the supply for the raw grinding machine—tube mills and Sturtevant emery stones—is drawn. Following the grinding, the slurry is conveyed to receiving tanks, where it is tested, and if necessary, corrected by the addition of the constituent lacking. Pumping from these tanks to large steel or concrete storage tanks, ten in all, having a united capacity of two thousand five hundred barrels, where the mix is again tested, completes the preparation of the material. To prevent settlement of the heavier part of the mixture, air under a pressure of ninety lbs. per square inch is carried down vertical pipes to within a few inches of the bottom of the storage tanks. This keeps the slurry in a state of constant ebullition, and is found to be a most successful method of attaining an end much desired.

A floor trough with its axis perpendicular to the axes of the rotary kilns and almost directly beneath their high ends, receives its supply from any or all of the storage tanks as desired. A revolving "beater" running the entire length of the



The Canadian Portland Cement Co., Marlbank plant. In the little "bottle" kiln shown in this picture was manufactured the first Portland cement made in Canada.

trough prevents settlement of the slurry prior to its being pumped into the kilns. The pumps have adjustable crank pins, so that the length of stroke, and consequently the quantity of slurry pumped is under complete control.

The Marlbank plant has nine rotary kilns, four being ninety-five, and the remaining five sixty feet long. The longer ones on the whole give the better satisfaction, and of course have a much larger capacity per diem.

Ground coal is blown in at the lower end of the kilns, the speed of the kilns as well as the fuel supply being controlled by Mosser cone speed-regulators. The coal preparation plant consists of two forty-foot rotary driers, a Smidth ball mill and three tube mills in the order named. The clinker is elevated from the kilns and has its heat abstracted in four Mosser coolers, after which it is ready for the grinding room. Grinding is done in two No. 7 Smidth ball mills and a Smidth kominuter, the two being similar in principle. Tube mills complete the grinding of the cement, and as

As usual with these machines, they are lined with silex (flint) stone. The product from the preliminary grinding is admitted through the trunnion, and is discharged at the opposite end. A conveyor carries the finished cement underneath the Bay of Quinte switch to the storehouse on the opposite side.

The power required is supplied by a Wheelock tandem compound six hundred horse power condensing engine, two others of the same style of three hundred and fifty horse power each and an "Ideal" for electric lighting purposes. The plant is provided with a machine shop equipped with all machines necessary for making ordinary repairs, a brass foundry and a most complete laboratory and assay office. A library and comfortable reading room supplied with magazines and current literature is provided for the entertainment of the workmen. The capacity of the plant is one thousand three hundred and fifty barrels per day. "Star" cement enjoys a favorable reputation, and is marketed from coast to coast.

The Colonial Portland Cement Company

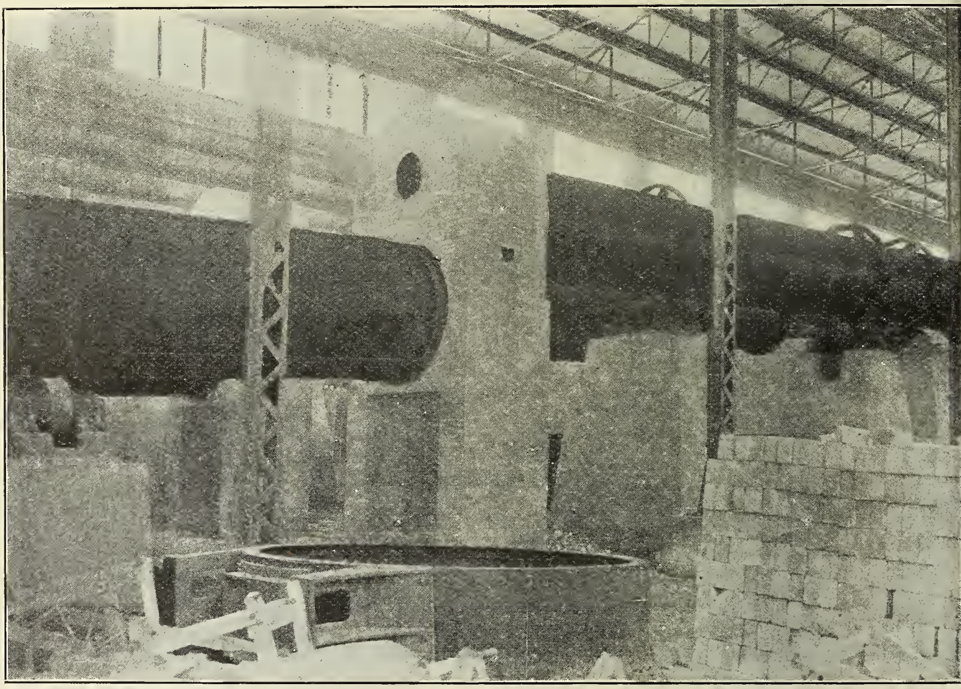
President ....Elbert L. Buell
Vice-President ....E. Young Jackson.
Secretary-Treasurer.......................... David A. Wright, Wiarton, Ont.
Authorized capital ....$800,000.
Works ....Wiarton.

General view, The Colonial Portland Cement Co., Wiarton.

The plant of the Colonial Portland Cement Company is located on Colpoy's bay on the outskirts of the picturesquely situated town of Wiarton, and is in a fair way to early completion. The Grand Trunk railway has extended its lines to the plant, and thus the company is in a position to ship by rail as well as by water. A shipping dock 800 feet long founded on piles and cribwork, and rendering available a depth of water of 14 feet has been constructed. This is provided with a tramway which runs from the boats to the mill.

The properties owned by the company which afford a supply of raw materials are in two separate localities. The first of these, portions of lots 9, 10 and 11, concession 22 and 23 of the township of Keppel, is but a mile and a half from the works. It is a marsh-like area, capable of easy drainage, and comprises one hundred and eighty-nine acres, with a depth of marl running to five feet. Clay underlies the marl. A growth of peat a few inches in thickness will necessitate a little preparatory surface stripping. A line of railway to connect this deposit with the works is in process of construction by the company. The gradient to the plant is falling throughout, thus facilitating the carriage of materials to the mill.

The second area available is known as lake Scales, and is four miles from the plant. This lake is extremely shallow, having less than two feet of water. The area is 205 acres, and the depth of marl is from five to twenty-seven feet. As in the



The Colonial Portland Cement Company. Rotary kiln. The lower portion is the kiln proper ; the upper is the dryer.

previous instance, a stratum of clay underlies the marl. This has a depth of two to eight feet. A survey of the lake has been made with a view to ascertaining the quantity of marl available. This has been estimated at four million cubic yards. In addition there is a quantity of shale obtainable from White Cloud island convenient to the works, which investigation has shown, will be extremely useful in the process of manufacture.

From a trestle work on the company's line, the raw materials can be dumped conveniently for handling at the beginning of the process. The marl will pass through Bonnat separators which remove stones and other *dèbris*. Then it will pass to a concrete storage pit. The shale if employed will be reduced in some form of crusher. After proportioning, the two materials will be mixed with the necessary quantity of water in Bonnot pug mills of four cubic yards capacity each, after which the mix will be transferred to storage pit number two. The separation of the ingredients is here prevented by rotary blade agitators. The raw grinding will be done in tube mills to

which the slurry will be pumped from the storage pit. From the tube mills it is discharged to storage pit number three, and is thence pumped into the storage tanks which supply the kilns. These storage tanks, of which there are three, are of concrete construction with external batter faces. The walls are reinforced peripherally by imbedding a series of strands of steel rods seven-eighths inch in diameter. The intention is to have one tank filling while a second is being corrected, and the remaining one is being drawn on for the kilns. Compressed air will be employed here to agitate the slurry.

The rotary kilns installed by the Colonial Cement Company present some features peculiar to themselves. The kilns are of a length over all of 105 feet, but are in two separate parts, each capable of its own independent motion. The upper portion into which the slurry is pumped from a transverse trench is known as the "drier" and is forty-five feet in length and five feet in diameter. A brick pier provided with an internal chute or incline leading from the lower end of the "drier" to the upper end of the kiln proper separates the two portions of the kiln. The result is that the axes of the two portions are not continuous the one with the other, but parallel, that of the kiln proper being slightly lower. The kiln proper is sixty feet long and seven feet in diameter. Four kilns are at present in place, and room for four others has been provided.

The clinker will be conveyed to Mosser tower coolers, from which the hot air is drawn by suitable fans and passed into the upper or drying portion of the kiln. Here it assists the gases from the kiln in the process of water expulsion. To further hasten the process of drying, a series of sections or tumblers have been riveted to the interior of the "drier." These will the better expose the fluid slurry to the action of the hot air and gases. It is estimated that the mix will be reduced to a twenty per cent. moisture condition when it leaves the drying portion of the kiln.

The clinker grinding apparatus has not yet been installed, but will probably be a battery of Griffin mills. Ground coal will be the fuel employed in the kilns, and an attempt will be made to instal a dust proof coal drying and grinding system.

Power will be supplied from three cross compound condensing engines of 400-h.p each. One will transmit to the dry grinding plant through a rope drive, and the other two will be direct connected with Fulter-Westrom Swedish generators. A battery of four Stirling water tube boilers made in Barberton, Ont., supplies the steam. Individual motors will be generally employed. The company's prospectus anticipates an ultimate output of one thousand barrels per day.

The Grey and Bruce Portland Cement Company

President	Jas. McLaughlin.
Vice-President	John Lind.
Secretary-Treasurer	A. D. Creasor, Owen Sound.
Authorized capital	$500,000.
Works	Brookholm, Ont.
Brand	"Hercules."

Like the Sun Portland Cement Company, the Grey and Bruce syndicate began manufacturing by the dry process. The change to the wet slurry system was made in September 1904, and has proved satisfactory, a more uniform mixing, and a better brand of cement being obtained. Further, under the old order of things, elevators were constantly getting choked with dust, and journals and other moving parts subjected to incessant wear.

Marl is obtained at Shallow lake on the Harriston and Owen Sound branch of the Grand Trunk railway, some nine miles distant. At present, it is shovelled into flat cars, which are hauled in by the G. T. R., but the company contemplates putting in a dredge. Blue clay, obtained a quarter of a mile from the works, is blasted with

dynamite and teamed to the mill. The construction of a narrow gauge track from the works to the clay pit is another contemplated improvement.

The company have constructed a coal and shipping dock on the bay, and this together with suitable piers and elevated trestles facilitates the economical handling of raw materials, coal and the manufactured article.

From the elevated trestle the marl is conveyed in narrow gauge cars each of one cubic yard capacity, to the washmill. The clay is stored under a roof, and is weighed into the crusher, which in turn discharges into the washmill. In the opinion of the superintendent, however, quite as good results will be obtained without crushing the clay, and hence this part of the process may shortly be abandoned.

The washmill is of concrete, octagonal in form, and is supplied with three drags. The mix gradually works through a grating into a pit, from which it is elevated to two pairs of Sturtevant vertical emery stones. From here it is pumped to the storage tanks, four of steel and one of wood, which supply the kiln trough. This pump is a double cylinder one, and it is so arranged that pumping may be done into any one of the five. The slurry is tested when a tank is nearly full, and is not used until the mix is satisfactory. A tank of slurry can be corrected in the space of half an hour. Compressed air is used to agitate the slurry. The method of piping compressed air into the trough beneath the kilns has recently been abandoned in favor of a screw agitator. One of the three kilns is seventy feet long, the others being but sixty. These were supplied by the Vulcan Iron Works Company of Wilkesbarre, Pa., and by the Bonnot works. The speed of the kilns and the supply of ground coal are both controlled by Reeves' drives. The clinker is elevated from the kilns and conveyed to the clinker room, where it is allowed to cool in air. No mechanical cooler is employed.

The grinding is done in Krupp ball and tube mills. Before being admittted to the first of these mills, the clinker is weighed. The cement is finally conveyed to the stock room where the packing is done. The company ships in barrels, and in paper and cotton bags.

The coal is first crushed between rolls, passed through a rotary Cummer drier and then ground in a Griffin mill. Power for the plant is supplied by a 450-h. p. Jerome-Wheelock compound tandem engine, made by Goldie and McCulloch of Galt, and a 150-h. p. "Ideal" for electric lighting.

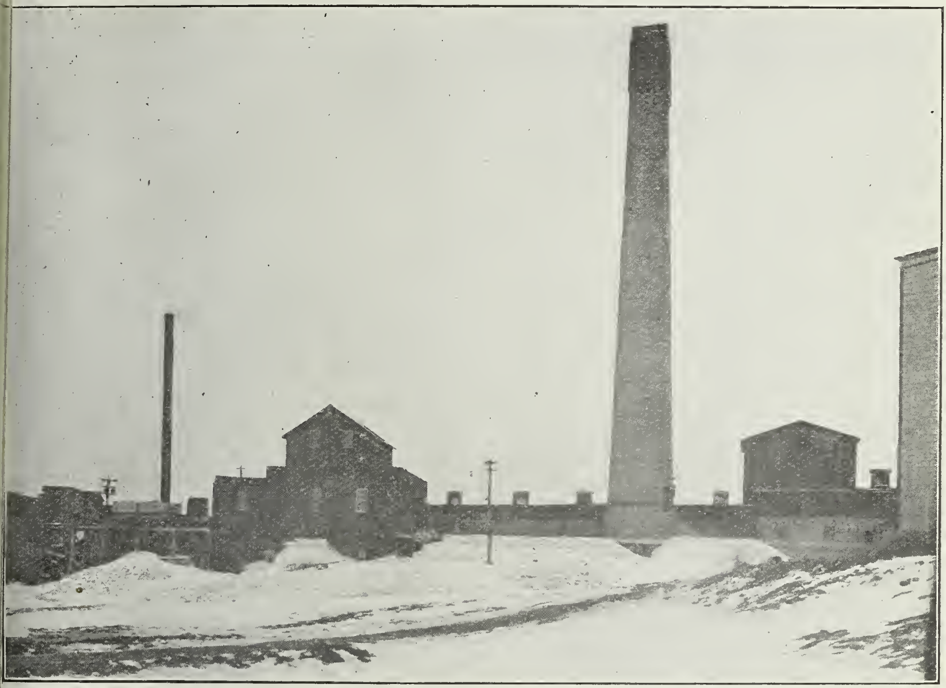
The company has purchased upwards of 400 acres of marl deposit, of which the upper seven feet are said to be of good quality. Below this, the quality seems to deteriorate. The result is that while a good grade of cement is possible from marl taken from greater depths, the expenses of manufacturing are considerably higher. Six acres of clay of a depth of fifty feet is the available supply at present. No surface stripping is necessary, although in the case of the marl, about one foot of peat has to be removed. The present output is 200 barrels per day, but with the addition of two more kilns and the necessary storage tanks and grinding machinery, the capacity will doubtless be doubled. The buildings are of limestone and brick. All machinery is supported on massive piers. A properly equipped laboratory is maintained, and a competent chemist employed.

Hanover Portland Cement Company

President and Managing Director .... D Knechtel, Hanover, Ont.
Vice President .... Jas. H. Adams, Hanover, Ont.
Secretary-Treasurer and Manager......... Milton J. Müter, Hanover, Ont.
Authorized capital ....$500,000.
Works .... Hanover, Ont.
Brand ...."Saugeen."

This company has been manufacturing Portland cement since the summer of 1898. The works are situated on the Saugeen river convenient to a waterfall which supplies a maximum of five hundred horse power during four months of the year

For the development of this a suitable power house has been erected. Two Samson turbines and a generator have been installed, and the power electrically transmitted to the works, a distance not exceeding a quarter of a mile. It has been found necessary to supplement the work of the turbines during the dry season, and for this purpose steam is employed.



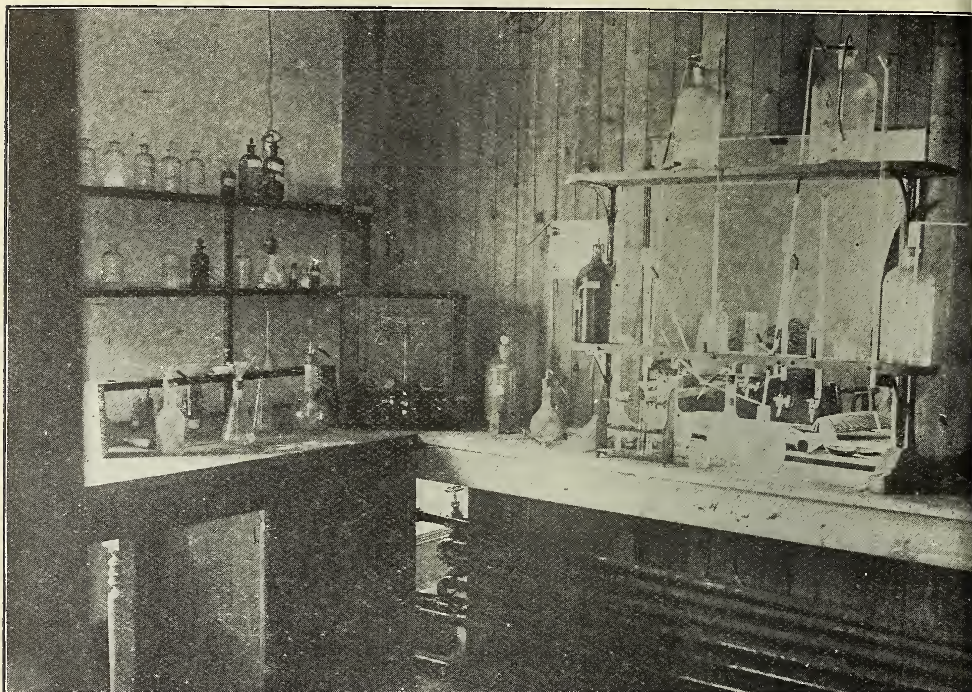
The Hanover Portland Cement Company. General view of works. The rectangular stack in the picture belongs to the Batchelor kilns.

In the township of Brant, a mile and a half from the works, are situated the company's marl deposits, comprising 150 acres of a depth of sixteen feet. The surface is covered with a growth of peat from six inches to a foot deep. Clay underlies the marl deposit, but is also found in the hill adjacent to the plant in sufficient quantity for the entire marl available. This supply is at present being used. The marl is raised by clam-shell dredge, filled into specially constructed dump cars, and hauled to the mill by a locomotive on a three-foot gauge track. The clay is filled into carts by hand and teamed to the mill, a distance of only a few hundred yards.

The marl is dumped in measured quantities from the track trestle into a wash-mill, into which the clay is also weighed. Following this, the grinding is done in emery stones and the slurry stored in two tanks each of one hundred and fifteen barrels capacity. Rotary stirrers in these tanks prevent the separation of the materials.

The burning is done in eight kilns of the Batchelor type elswhere described. The slurry is piped to the drying floors beneath the arches leading from the kilns to the stack, and when sufficiently dry is moved forward to the burning chamber by hand. The arches are 45 feet long and the interior diameter of the kiln proper is about nineteen feet. Twelve furnaces on an average are drawn per week from the eight kilns.

Grinding of the clinker is done in Smidth ball and tube mills, a jaw-crusher being employed for the preliminary reduction. A belt conveyor carries the finished cement to a store room of twenty thousand barrels' capacity. Packing is done entirely in bags. The outcrop of the plant is two hundred barrels per day.



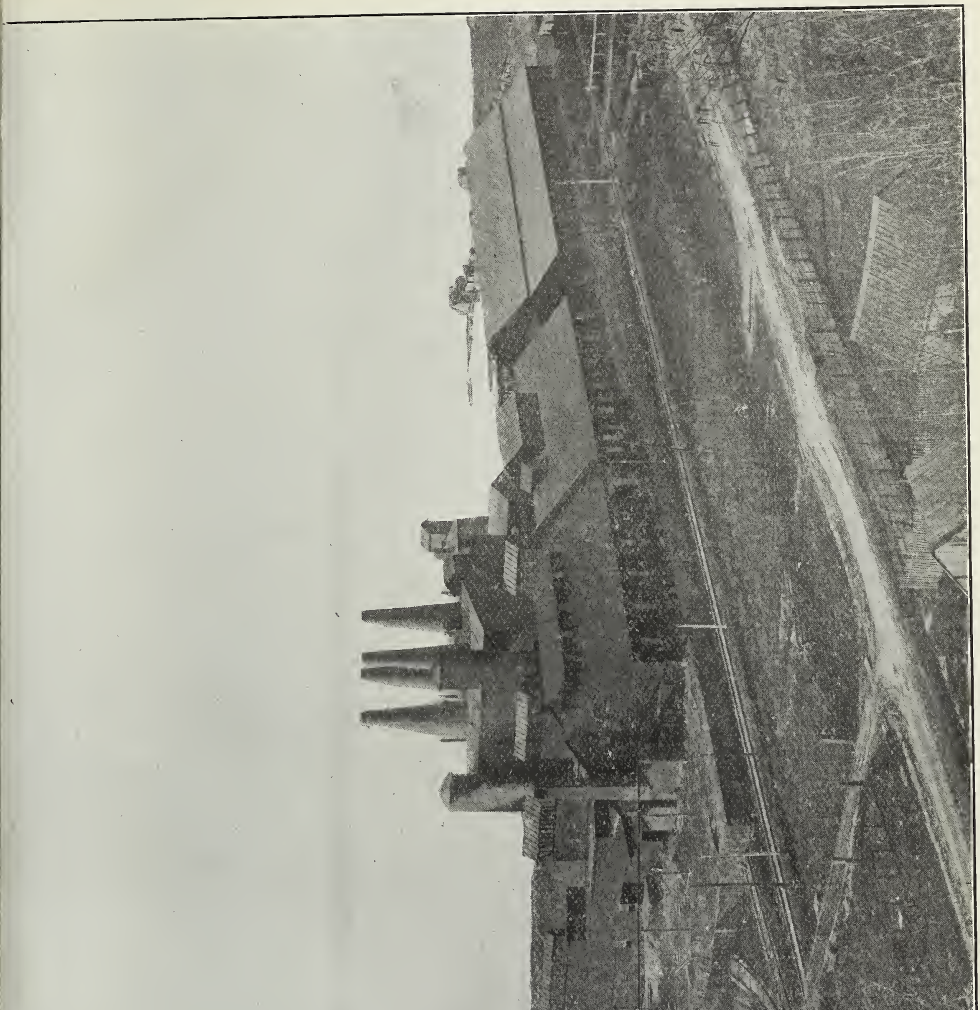
Hanover Portland Cement Co. The chemical laboratory.

The Imperial Portland Cement Company

President	M. Kennedy.
Secretary-Treasurer	J. W. Maitland, Owen Sound.
Authorized capital	$250,000.
Works	Owen Sound.
Brand	"Imperial."

The semi-wet method of mixing renders the process of making "Imperial" cement quite different from most of those at present in vogue in Ontario, though quite similar to that in use at Strathcona until a year ago. The clay is first passed between a pair of plain rolls driven at different speeds. Then it is dried in a rotary Ruggles machine, from which it is conveyed to the emery stones, which reduce it to a powder.

A Ruggles drier consists of two cylinders made of boiler plate, with a common axis, this axis as is usual with rotary driers being set on a slight incline. A furnace for the reception of the fuel—slacked coal in this instance—is provided beneath the lower end. The furnace gases pass down the inner tube, and are then admitted to the annular space between it and the outer one. They return by this passage to the stack immediately above the furnace, and in so doing come in contact with the material to be dried, which is admitted to this same passage from the upper end. Channel irons are rivetted to the outside of the inner cylinder and to the inside of the outer, and the revolving motion given to both insures to the material a thorough tossing and consequently, a pretty complete drying.



Imperial Cement Co., Owen Sound. The four conical stacks are those of the four Alborg kilns.

After grinding, the clay is stored in three tanks provided with hopper scales, by means of which it is weighed into the "mixing pan," into which the marl after being weighed is also dumped. This "mixing pan" is in the form of a shallow cylinder and has a vertical centre shaft. This shaft carries two horizontal arms constituting virtually a diameter of the so-called pan. The extremity of each arm is the axle of a ponderous wheel or roller which through the rotary motion of the upright shaft is made to take a circular path also around the bottom of the pan.

Part of the mix from the pan goes through a second Ruggles drier, the rest going at once to the pug mill, and from it to the brick machine. The object of drying a portion only is to enable the operators by mixing the dried material, with the undried to secure any desired plasticity at the exit from the pug mill. The brick machine is provided with an expression screw and a nozzle measuring ten inches by four and a half inches. From this nozzle a constant "stream" of stiff mortar-like slurry is delivered to a carrying belt. An operator with a wire "cutter" chops this "stream" into bricks four or five inches wide. These bricks are then loaded by hand on cars having suitable frames which are run into drying tunnels one hundred feet long. Of these, there are fourteen. Each tunnel can accommodate fifteen cars. Here the bricks for some thirty hours are exposed to a blast of hot air supplied by two forty-eight inch fans. At the end of this time they are quite dry, and the cars are run out and elevated with their load of bricks to the charging floor of the Alborg kilns. There are four of these kilns, and from the highest floor the bricks are charged into the furnace. On the next floor the stoking is done. The burning takes place largely below these fire-holes, and the cooling below this in turn.

The clinker is drawn from below four times in twenty-four hours.

The grinding of the clinker is done in Smidth ball and tube mills. Packing is done in bags and barrels by hand. The capacity of the plant is three hundred barrels per day, and the cement is marketed chiefly in Ontario and the Canadian west.

The marl is obtained from Williams lake, in Holland township, a distance of thirteen miles from the plant. The area is one hundred acres, and the depth exceeds thirty feet on the average. It is brought to the works by the Canadian Pacific railway. Both red and blue clay are used, the former being a quarter of a mile from the works and the latter across the bay, on which the company has constructed a good shipping dock. In this latter place there is a deposit of one hundred acres in extent.

The management are contemplating some radical changes in the plant with a view to adopting the wet system of mixing.

The International Portland Cement Company

President .... W. F. Cowham.
Vice-President .... A. F. MacLaren, M. P., Stratford.
Secretary .... P. W. Stanhope, Toronto.
Treasurer .... D. Jamieson, M. D., Durham.
Authorized capital .... $1,000,000.
Works .... Hull, Que.

Though not situated in Ontario, being just across the Ottawa river at Hull, in the Province of Quebec, these works, at present in process of erection, are largely owned by men interested in cement manufacture in Ontario, and when completed, will be the largest in Canada. Like the Belleville plant, this one will use limestone instead of marl, both it and the clay being obtained in practically the same place. The company has acquired an area of over four hundred acres, three hundred of which is limestone sixty feet in depth, the remaining being clay. The limestone is said to be remarkably uniform in composition at all depths, varying scarcely more than one per cent. in lime content.

The plant is being erected on the shore of lake Leamy, near the city of Hull, which without much cutting can be connected by navigable canals with the Gatineau and Ottawa rivers.

A unique feature of the equipment is the method to be adopted in bringing the raw materials from the quarry and clay beds to the works. Huge wooden towers have been erected, two at the raw material buildings and other two at points where the limestone and clay can be loaded for transportation to the plant. Stout cables have been stretched from top to top of these towers, and from the cables cars will be swung. The raw materials will thus be rapidly and cheaply transported to the mill. The span between the towers for the limestone is sixteen hundred feet, and between those for the clay, eleven hundred.

The clay will be first passed through a disintegrator, and thence conveyed by inclined belt upward to two rotary driers sixty feet by six. By a screw conveyor, it will pass to an edge runner, and by elevator to the clay storage room, a building 110 by 56 feet, and having a capacity of seven thousand tons, equal to four months' consumption. This storage room has a tunnel underneath into which sixteen hoppers from the room above can discharge. In this way, clay from any part of the building may be drawn on for the daily needs of the kilns. the supply for which is always taken from below by screw conveyors located in the tunnel. Measuring hoppers constructed on a telescopic principle so that their capacity may be altered as desired are employed here to measure volumetrically the clay prior to its being admitted to the Gates tube mills. The output of these tube mills will be of sufficient fineness to pass ninety-five per cent. through a number one hundred sieve. The material will be next elevated to hoppers which feed the rotary kilns.

The limestone will be brought to the mill by a device identical with that by which the clay is to be handled. A large Gates' crusher will first reduce the rock to a 1½-inch size, after which it will be sorted in a revolving screen; that which is rejected by the screen will go through a second Gates' crusher, after which it and the finer size from the first crusher will be conveyed to the stone storage room. The crushers are to be driven by individual electrical motors.

The stone storage room is of design similar to that of the clay storage room, and has the same style of drawing tunnel underneath. A bucket conveyor completely surrounds the room, passing through the tunnel underneath. A "tripper" at the roof is mounted on a track so that the stone can be discharged wherever desired. Surface water on the stone running to perhaps 1½ per cent. is removed by rotary driers similar to these employed to dry the clay. After being dried, the limestone will be conveyed to hoppers, which in turn will feed the Krupp ball mills which are to reduce the stone to 20-mesh. This grinding will be completed in the tube mills.

The burning will be done in a battery of eight rotary kilns each sixty feet long. Provision will be made to utilize the heat from the rotaries in warming the buildings. The clinker will be cooled by drawing a blast of air over it after it drops from the rotary kilns. The heat thus evolved will be employed in drying the coal.

The clinker grinding will be done in ball mills and tube mills. Most complete arrangements for handling the clinker, for transporting to and from the grinding machines, and for storing and packing the finished product, are being made. The total floor space will be three and a half acres. The buildings are of a most substantial character, the foundations being concrete, and the walls up to ten feet from the ground being artificial stone. Expanded metal is largely employed for the upper portions of the walls and for the roofs.

Coal for fuel in the rotaries, as stated above. is first dried, then crushed, and finally ground in tube mills. The store room for crushed coal is 200 feet by 48 feet, and has a very complete type of continuous conveyor that can be used either for filling or emptying.

Power will be obtained from one of the Hull water power companies at the low price of $15 per horse power per year. This is a factor which will no doubt contribute to the economical operation of the plant. In addition to this, the company has purchased the water rights and lands necessary for the development of a fine water

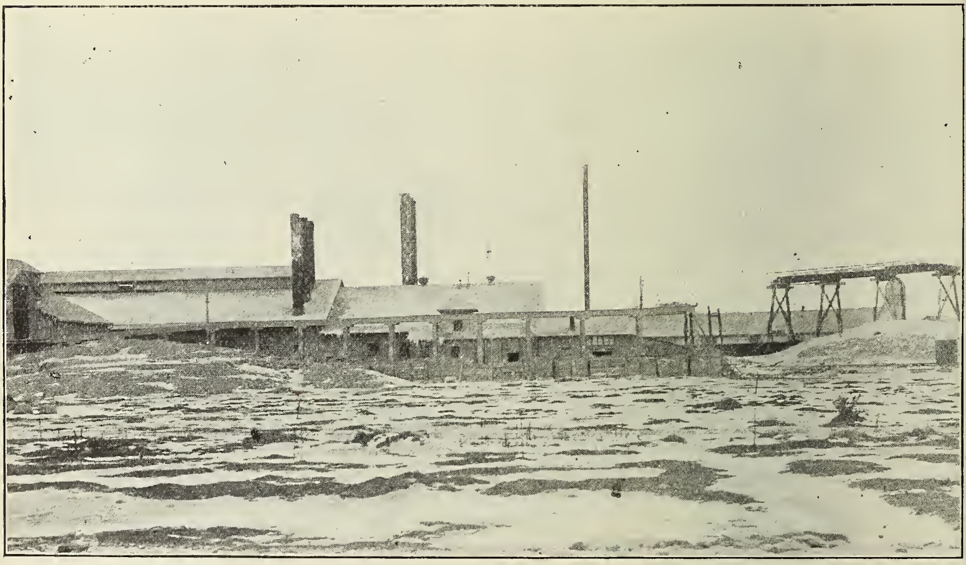
power on the Gatineau, known as the Cascades. It is said that at low water over 14,000 horse power are here available, and that the expenses of development will not be excessive.

Regarding shipping facilities, the prospectus of the company has this to say: "The two raw materials lie side by side and distinctly separate from each other at the connection of the Canadian Pacific railway, the Canada Atlantic railway, the New York and Ottawa railway, the Ottawa and Prescott railway, the Northern and Western railway, the Rideau canal, and the Gatineau and Ottawa rivers."

The company expect to begin manufacturing operations during the summer of 1905.

The Lakefield Portland Cement Company

President	J. M. Kilbourn.
Vice-President	R. P. Butchart.
Secretary-Treasurer	F. A. Kilbourn, Lakefield, Ont.
Authorized capital	$1,000,000.
Works	Lakefield, Ont.
Brand	"Monarch."



The Lakefield Portland Cement Co., Lakefield. General view of plant.

The Lakefield Portland Cement Company, Limited, began manufacturing on the 2nd day of January 1902. For the purpose of getting access to some eight hundred acres of submerged marl in the township of Douro, the company drained Buckley's lake, which is one and a half miles from the village of Lakefield,the site of the works. The marl is transported this distance in the company's own steel dump cars, hauled by its own locomotives over its own railroad. Clay is obtained from Lily lake in the township of Smith, on the Midland division of the Grand Trunk railway. It covers an area of twenty acres and varies in depth from five to fifteen feet.

Excavation from both deposits in carried on by means of immense steam-operated hydraulic elevators, which, plying on a track of fourteen feet gauge, are self-propelling and lift, carry and lay their own track in thirty-feet sections. Each will load, under favorable conditions, a thirty-ton flat car in seven minutes. The marl averages nine feet in depth, but reaches twenty feet in places.

In a single rotary washmill, the raw materials are given their preliminary mixing. This mill consists of a cylindrical basin eighteen feet in diameter, provided with two feeding chutes, one for marl and one for clay at opposite sides. The former is measured by volume; the latter by weight. The basin is provided with a vertical centre shaft that carries horizontal arms to which heavy "drags" are attached. The shaft is made to revolve and the mixing of the two materials is thus more or less completely accomplished. To secure a still more perfect incorporation of the two ingredients, the mix is passed through emery grinding stones and thence to tube mills. Unlike many others, these mills are lined with wooden blocks sawn to the proper arc, which may be easily removed and replaced by others when worn. Six cylindrical concrete and six wooden storage vats receive the slurry after the raw grinding is completed, the method being to test and correct the mix in each before admitting to the kiln pumps. It is so arranged that any one tank ar any number of tanks may be receiving slurry at any time, while the supply for the rotary kilns is drawn only from those in which the mixture is known to be correct. Sufficient slurry for forty-eight hours' burning may be easily stored here.

As in another plant previously described, a trough transverse to the axes of the kilns receives the slurry from the storage tanks. The method of agitating by compressed air is employed here, as it is in the storage tanks, and is reported as being eminently efficient.

Pumps supply the rotaries, of which there are six, three being sixty feet and three one hundred feet long. The former revolve at the rate of sixty revolutions per minute, and the latter at about forty. The upper ten feet of the length of each kiln has large channel irons rivetted on the inside of the kiln longitudinally. These serve by tossing the semi-fluid slurry, the better to expose it to the hot gases, and assist in the expulsion of the water. The shorter kilns are said to give the better satisfaction. The usual methods of controlling speed, feed of slurry and of ground coal to the kilns are employed here.

The kilns discharge into a horizontal conveyer, and the clinker is ultimately elevated and admitted to rotary cylindrical coolers. These are provided also with channel irons rivetted to the inside of the cylinder. Cool air is drawn through these coolers, and after taking up the heat of the clinker, is delivered by blower to the ground coal kiln feeders.

The grinding of the clinker is accomplished by ball and tube mills, both Krupp and Bonnot makes being employed.

Slaked coal is dried in a revolving drier, and then pulverized in Raymond vertical mills.

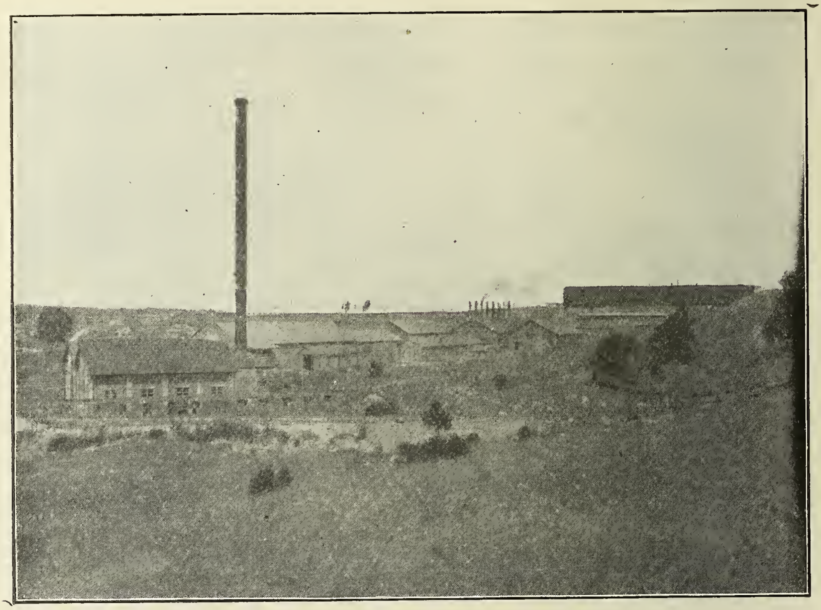
Power is obtained from lock No. 3 of the Peterborough-Lakefield section of the Trent canal, three miles distant, and also from Young's Point, five miles from the plant. Generators are provided at each place, and the electrical energy wired to the place of consumption. These powers are constructed to operate jointly or singly, and either is capable of carrying on the work of manufacture, so that a "shut-down" of the works on account of lack of power is never feared.

The output is between six hundred and seven hundred barrels per day. Export of cement and importation of coal for fuel are as yet almost wholly by rail, but the completion of the Trent canal will undoubtedly mean the utilization of water for both purposes to a very great extent.

The National Portland Cement Company

President	W. F. Cowham.
Vice-President	A. F. MacLaren, M. P.
Superintendent	H. H. Farr, Durham, Ont.
Authorized capital	$1,000,000.
Works	Durham, Ont.
Brand	"National."

The National Portland Cement Company began the manufacture of cement early in 1903. The works stand at the bottom of a rather steep declivity, and the railway supplying the raw materials is continued from the plateau on a level steel trestle over the storage rooms, thus facilitating the unloading very materially.



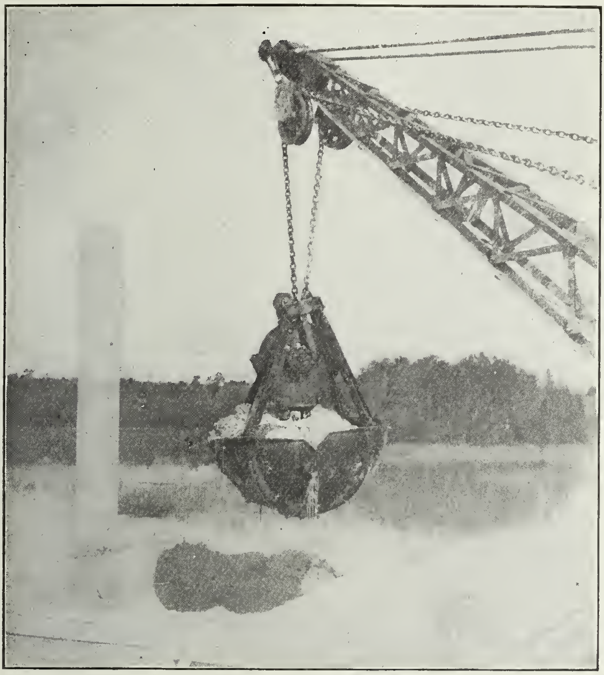
National Portland Cement Co., Durham. General view of works.

Wilder's lake, five and a half miles from Durham, and Tobermory lake in the same neighborhood, are the sources of the marl. The former has an area of 125 acres, and the deposit varies in depth from two to fifty feet. The latter is but fifty acres in extent. The overlying water is of a depth of twelve feet in places, and beneath this is an average of twenty-five feet of marl. Clay is brought from Stratford, a distance of sixty-nine miles, and is hauled to the works on flat cars. Of this, the company has acquired a deposit of forty acres.

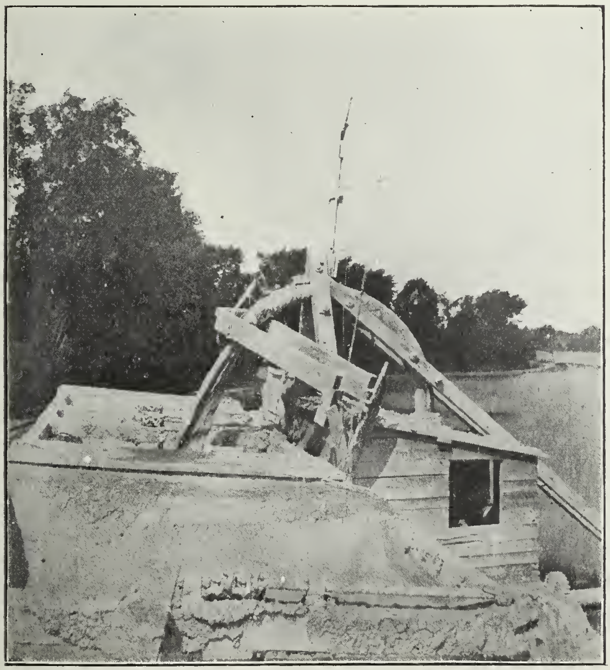
The marl is raised by floating dredge with an orange-peel dipper. This dredge is equipped with a stone separator and a pug-mill.

After passing through these machines the marl is conveyed through a flexible tube carried on a series of pontoons to the hopper-shaped cars on shore. The "Harris" system of conveying by compressed air is here employed, and is said to work to the utmost satisfaction.

The clay is fed into a plain rolls disintegrator, and after passing through a cylindrical rotary drier 50 feet long and five feet in diameter, is conveyed to a Phillips and McLaren dry pan. This consists of a pan containing a pair of huge upright wheel-like "molars" similar in construction to the at one time familiar "edge-runners." The pan has a moveable meshed bottom, so that the size of openings can be altered from three-eighths to five-eighths of an inch. The pan is made to revolve while the axis of the molars retains its fixed position. The clay is thus pressed through the meshes and reduced to the desired size. It is then fed to a conveyor and passes to the dry clay storage room 100 by 60 fet. Here the chemist takes samples for analysis every hour of the twenty-four.



National Portland Cement Company. Orange peel dipper.



National Portland Cement Company. The Harris pneumatic system of pumping marl.

Running longitudinally with the dry clay storage room and beneath its centre line is an underground arched tunnel, carrying a bucket conveyor. The roof of the arch is provided with hopper-like openings, which may be opened or closed at pleasure. The dry clay may thus be drawn from any part of this building and transferred to the wet department. It has been the practice of the company to store during the open season a quantity of clay for winter consumption, and for this purpose a large wet storage room from which the drying plant is conveniently supplied, has been erected. The dry clay is delivered to the mixing pug mill by measuring hoppers, each of about 600 pounds capacity.

The marl is brought in on the high level trestle above referred to and dumped into a hopper of two cars capacity, which supplies the marl pug mill. From here it is conveyed to a battery of nine marl storage tanks, at the bottom of each of which a series of pipes delivers compressed air through bent nozzles. This imparts to the fluid a swirling boiling motion completely preventing settlement. These tanks stand on a series of step-like piers that gravity may assist the flow of marl to the "mixing pug mill," where the marl and clay first come together. The tanks are further supplied with floats, enabling the operator in accordance with the chemist's instructions, to draw any depth of fluid marl to mix with a known quantity of clay. The output of the mixing pug mill is automatically transferred by the Harris compressed air devices to the tube mills, of which there are four. It is then transferred by the same method to eight steel slurry tanks. From an open "header," supplied by compressed air from these tanks, the kilns are fed. A revolving disc carrying a number of buckets which alternately fill from the header and discharge into the tube supplying the kiln, accomplishes this step. The speed of the disc varies with that of the kiln.

There are eight rotary kilns 70 by 6 feet, which are capable of being run at different speeds. The clinker drops into pits built beneath the kilns. Here it gives up a portion of its heat to air, which is in turn mown with the ground coal into the rotaries. The clinker then passes by chute into the water-tight buckets of a McCausland conveyor, which is at this point moving horizontally in a bath of water rising nearly but not quite to the edge of the pans. This conveyor completely surrounds the clinker storage room, passing through a tunnel underneath, up a vertical shaft at one end, along the roof and down again at the other end. A movable tripping device at the roof is so arranged that clinker may be emptied at any point desired. Further, there are hopper-shaped openings in the roof of the tunnel, so that clinker may be drawn from any part of the building. In this way, when the conveyor is not bringing fresh clinker to the room, it is feeding cold clinker into the hoppers supplying the ball and tube mills. The necessary quantity of gypsum is added after the material comes from the ball mills, and before it goes to the tube mills.

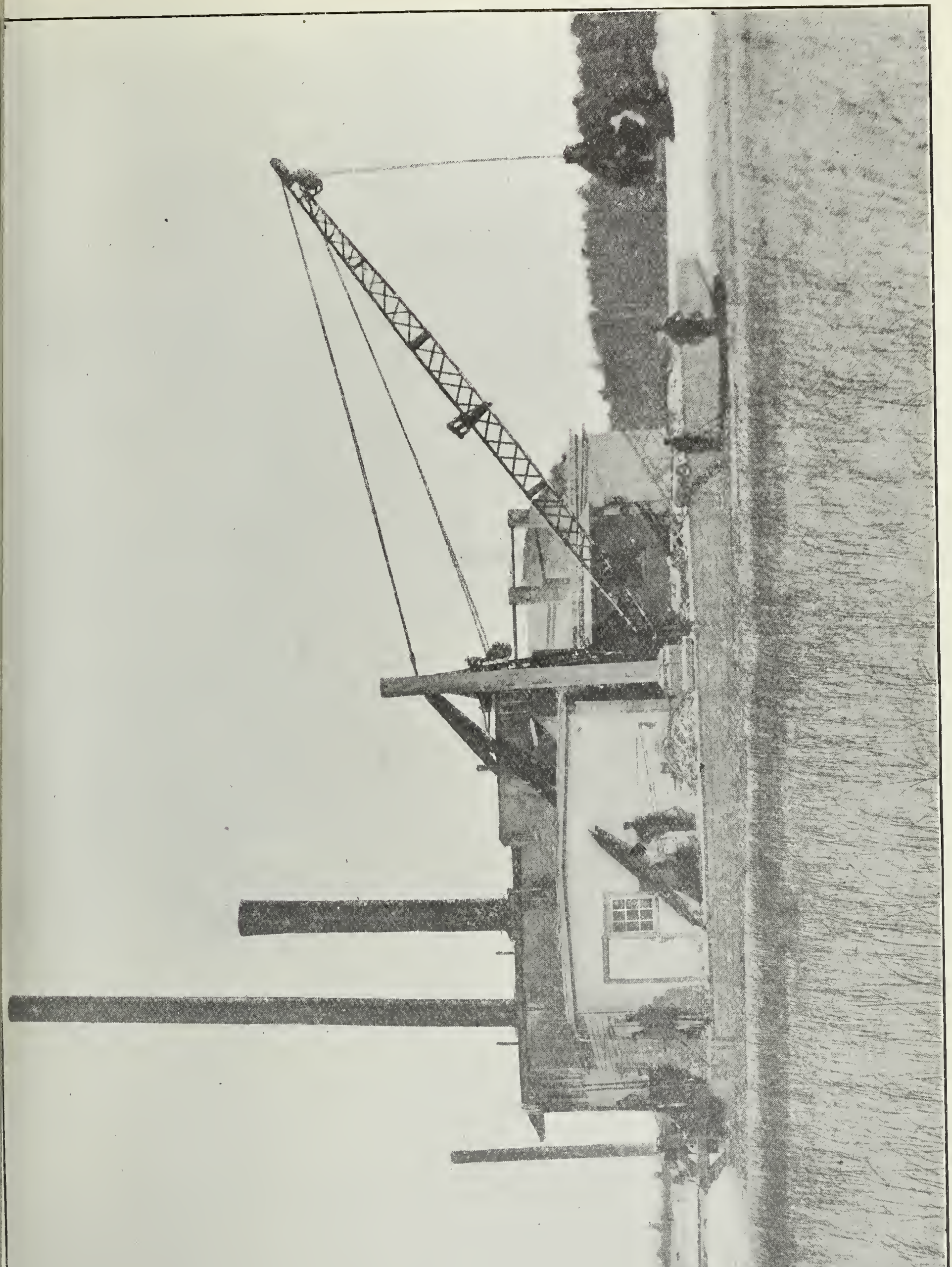
A belt conveyor carries the cement to the store room, and a tripping device similar in its purpose to the one previously described, is employed to fill any one of the eighteen bins in which the cement is stored.

Packing is done by three automatic machines of five hundred barrels each per day. Bags are employed almost exclusively, eighty-seven and a half pounds constituting a bag, and four bags being the equivalent of a barrel of three hundred and fifty pounds. The capacity of the plant is one thousand barrels per day. Ontario and the Canadian west absorb the output.

Coal for fuel for the rotary kilns is dried in rotary driers and reduced to a flour in improved Griffin mills. The power house is equipped with suitable engines and generators, driving by individual motors being the method generally adopted throughout the plant.

A most complete laboratory equipped with all the requisite appliances for making analyses and tests is maintained, and is in charge of Mr. S. H. Ludlow, a specialist in the chemistry of cements.

This plant, which undoubtedly is representative of the best modern practice, was designed by W. B. Bogardus of Cornell, N. Y.



National Portland Cement Co., Durham. Dredge equipped with Harris' pneumatic system of pumping marl.

The Ontario Portland Cement Company

President ....E. L. Goold.
Vice-President ....W. S. Wisner.
Secretary-Treasurer ....E. D. Taylor, Brantford, Ont.
Authorized capital .... $450,000.
Works ....Blue Lake, Ont.
Brand ...."Giant."

Blue lake is about three miles from the town of Paris, and is reached therefrom by electric railway. The plant stands on the shore of the lake, and at present the marl is being obtained not 600 feet from the works, to which it is brought in dump cars by locomotive. There are in this one deposit 100 acres running all the way from thirty-five to fifty feet in depth. A dredge will shortly be installed to supplant the present method of raising by manual labor. Fifty acres of clay of a depth of ten to twenty feet are available in one deposit beyond the lake. It is brought in by cars as is the marl.

In the process of mixing, the wash mill is employed. As is usual in such cases, the marl is measured and the clay weighed. The mix passes from the mill through a grating to a large rotary double agitator. A well adjoining receives the slurry from which by a large duplex pump it is conveyed to a hopper, above the tube mill.

After the process of grinding it is collected in two large concrete storage tanks reinforced by expanded metal. Compressed air is employed in these tanks to keep the slurry in a state of constant ebullition. Before being admitted into the supply trough, the contents of each kiln are checked by titration and corrected by the addition of whatever constituent is lacking. Three rotary kilns 70 by 6 feet are at present in use, but the management contemplate considerable additions to the plant. The velocity of the rotaries is controlled by a speeder, which is operated by the man in charge of the kilns. If the clinker should be discharged from the kilns insufficiently burned, the feed of slurry or the speed of the rotary can be reduced.

From the kilns the clinker is wheeled to the clinker room to cool. No special device to accomplish this is employed. The grinding is done in Krupp ball and tube mills, after which the cement passes to the stock house which is provided with eight bins of three thousand barrels capacity each. These are built on the "cribbing" plan, commonly exemplified in the construction of grain elevators. Power is conveyed to the coal-grinding plant from the power house by rope drive.

Coal for fuel is stored in bins under cover until required. Prior to grinding in the tube mill, it passes through a rotary Cummer drier.

The company has two shipping connections in the Grand Valley Electric railroad and the Grand Trunk railway, each of which has a spur running to the works. The former of these is owned by the company. The present output is 450 barrels per day, but will be increased this coming summer to 750 by corresponding additions to the plant. "Giant" cement seems to be well received, and the directorate report the demand for their product to be very good.

The buildings are of brick, steel and Redcliffe corrugated iron, and are as nearly fireproof as possible. The company has its own fire appliances. Boarding houses, workmen's cottages and laboratory have also been erected by the company. The post office of Blue lake is for the present in the company's office.

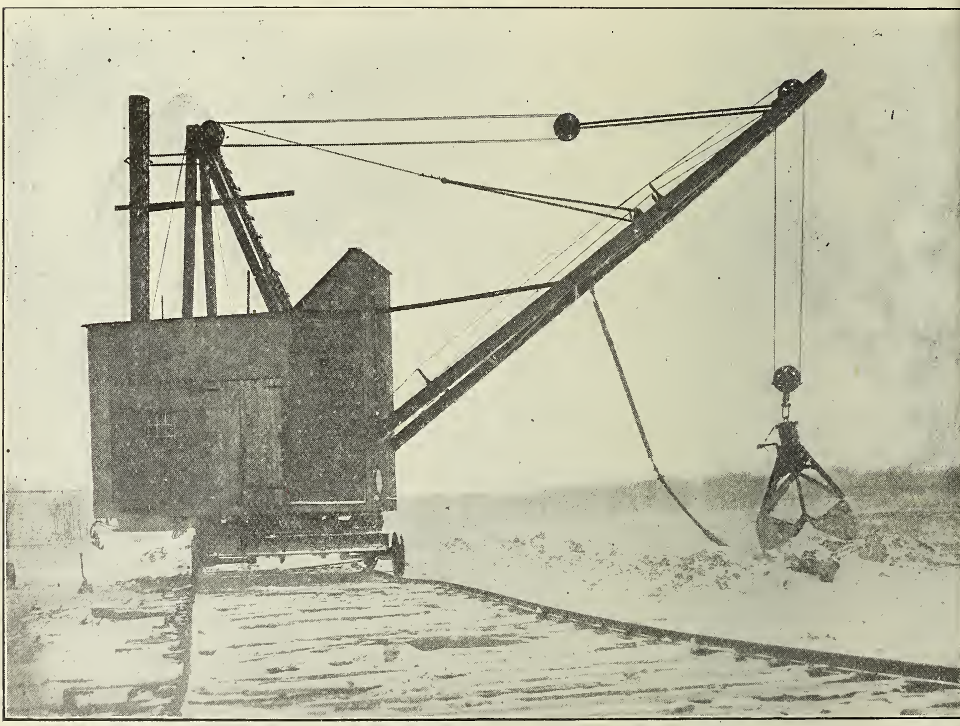
The Owen Sound Portland Cement Company

President .... J. E. Murphy.
Vice-President .... W. H. Pearson.
Secretary-Treasurer .... G. S. Kilbourn.
Works ....Shallow Lake.
Brand .... "Samson."

Owen Sound Portland Cement Company, Shallow Lake. Eight Batchelor kilns.

Away back in 1889, The North American Chemical, Mining and Manufacturing Company was organized at Owen Sound for the purpose of manufacturing Portland cement. Its capital was $100,000. A large building of masonry walls was constructed at Shallow lake in that year, and a plant subsequently installed. A Ransome cylinder was used in which to burn the cement, but proved unsatisfactory, and was abandoned, This industry was the forerunner of the Owen Sound Portland Cement Company, which to-day carries on a very extensive manufcaturing business.

Shallow lake occupies lots 6, 7, 8 and part of 9 in the seventh concession of the township of Keppel. The area is nearly 600 acres, including several small islands, and about 500 acres are under water for half of the year. "Two streams flow into the lake and in the dry season they unite near the works on the northern side, the channel continuing about 800 yards farther in a northwesterly direction towards the margin of the lake, where the waters disappear with a loud rumbling noise through a series of sinkholes in the bottom." The bottom of the lake is covered with marl to a depth of four feet, underneath which lies clay running to ten feet in places. A narrow gauge



The Owen Sound Portland Cement Co. Marl and clay dredge.

track has been constructed from the works out into the lake, and a locomotive and train of cars are employed to bring the clay and marl from the steam dredge to the plant. A contract was lately entered into with the James Cooper Company to erect tall towers and equip a system of cable transportation for the raw materials, but the new method has not yet been put into working shape.

The ingredients are mixed in a rotary washmill, the clay having been first put through a disintegrator. A Ferris wheel is used to elevate the slurry to a pair of Sturtevant emery stones. Nine large storage tanks have been constructed, into which the material is next pumped and in which it is agitated by compressed air.

The burning is done in nine Batchelor kilns, each having two drying arches, and in two rotary kilns each 100 feet long. These rotaries were originally 65 feet long, and the additional 35 feet were added to act as a drier for the slurry. They have a capacity of 120 barrels each per day. The Batchelor kilns are intermittent, it being the usual custom to get 14 kilns of clinker from the 9 furnaces each week. They are charged with alternate layers of dried slurry and coke, there being a 10-inch layer of the former to a 3-inch layer of the latter.

The clinker from the Batchelor kilns is first crushed before going to the ball and tube mills; that from the rotaries is first passed through a rotary cooler. The final grinding plant consists of two Krupp ball mills and three tube mills. The output of the plant is 700 barrels per day.

Ground coal is used for fuel, this being dried and ground in a Raymond grinder and in emery stones.

The power plant comprises an Inglis Brown 500-h. p. engine, a Corliss compound 350-h. p. engine, an air compressor made by the Rand Drill Company of Sherbrooke, Que., and a battery of five boilers. The company has its own fire protection plant, its own blacksmith and repair shop, and an extremely tidy office and laboratory made of cement blocks—a striking exemplification of the use of the article which the company manufactures. The management propose doubling the capacity of the works this present year. "Samson" cement is favorably known from coast to coast.

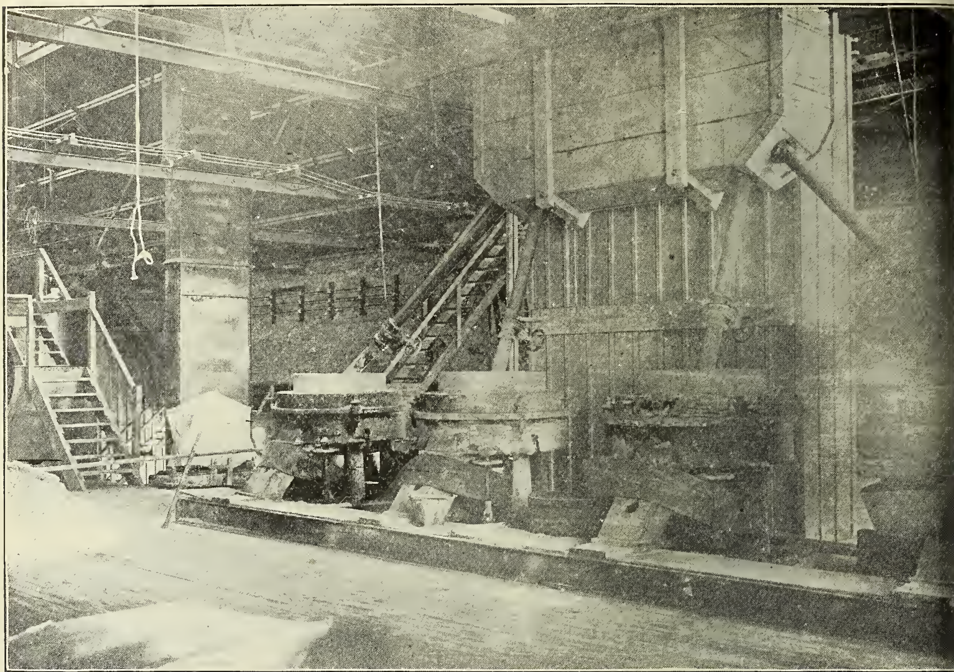
The Raven Lake Portland Cement Company

President	Gideon Shortreed.
Vice-President	Thos. F. White.
Secretary-Treasurer	Thos. McLaughlin.
Authorized capital	$500,000.
Works	Raven Lake, Ont.
Brand	"Raven."

The Raven Lake Portland Cement Company gets its name from the shallow lake from which its supply of marl is obtained, and on the shore of which its mills have been erected. Raven lake is situated on the Lindsay-Coboconk branch of the Grand Trunk railway, about two miles from Victoria Road station, and eighty-three from the city of Toronto.

From Elliot's falls on the Gull river, fifteen miles distant, the power necessary to operate the plant is electrically transmitted. A government dam has been constructed there which gives an available head of twenty-two or twenty-three feet, and in a series of small lakes farther up stream ample pondage facilities are provided.

The marl, which extends to a depth of twenty feet, is elevated from the lake bottom by means of a floating dredge and orange-peel dipper. This dredge is equipped with an air-compressor. As in the Durham plant previously described, the marl goes through a stone separator prior to being admitted to the Harris pneumatic pumping apparatus, which by compressed air conveys the marl to shore through a flexible pipe eight inches in diameter. This flexible pipe line connects the dredge and the raw material department in the mill, and is supported on a series of floating pontoons, each consisting of four coal oil barrels secured together by a suitable frame. The marl if not sufficiently fluid may be brought to the correct condition for piping by the addition of water. The pipe discharges into a huge marl storage tank. From this, the marl is admitted at pleasure to the mixer where it unites with the clay. The clay is at present obtained near Beaverton, and is brought thither on flat cars a distance of fifteen miles. It is first dried in a rotary drier, then ground in rotary emery stones, and finally elevated to weighing hoppers which empty, as does the marl, into the mixing washmill.



The Raven Lake Portland Cement Company. A battery of Sturtevant emery stones for raw grinding, etc.

Raven Lake Portland Cement Company, Raven Lake. General view of Works, etc.

Four slurry storage tanks are provided to which the mix is conveyed, and in which the contents are agitated by compressed air. The slurry grinding is accomplished in a battery of four Sturtevant individually electrically driven emery wheels.

The rotary kilns, of which there are four, may be considered as being divided each into two parts—a rotary drier and a kiln proper. These two parts are not continuous in alignment, but the former lies above the latter, their axes being in the same vertical plane. The slurry is admitted to the high end of the drier and is discharged from its lower end. Then it passes through grinding rolls, and is conveyed into the upper end of the kiln proper, in which the clinkering process takes place. The driers are forty-eight feet long and five feet in diameter, the kiln proper being 60 by 6 feet. An air current through the drier is secured by a rotary fan. The hot air from the kiln is made to pass through the drier and thus what would otherwise be waste heat is utilized.

The clinker is first cooled in a Wentz patent upright cylindrical cooler, then crushed in a Kent rolls mill and receives its final grinding in tube mills. The hot air from the cooler passes up the same chute as the one down which the clinker falls and goes into the kiln, thus effecting an economy in fuel.

Ground coal is used for fuel, the processes in its preparation being crushing, drying and grinding, first in rolls and then in tube mills.

The buildings are of limestone walls, with roofs of corrugated steel, supported on steel frames. The capacity of the plant will be four hundred barrels per day.

The Sun Portland Cement Company

President .... W. P. Telford, M. P.
Secretary-Treasurer .... John Armstrong, Owen Sound.
Authorized capital .... $500,000.
Works .... Owen Sound, Ont.
Brand .... "Sun."

By means of two towers with cable connection, and a clam-shell dipper, the marl required in the process of manufacture of "Sun" cement is unloaded from cars and transferred either to the marl heap or to a hopper which supplies through a chain conveyor, the marl washmill. The clay is brought in by teams, passes first through a plain rolls disintegrator, and thence by conveyor to the clay washmill. These two mills are adjacent and each supplies by a chute its contents to a large double agitator. This in plan suggests a huge 8. About the centre of each segment, a set of "drags" is made to revolve on a vertical shaft. The mixture is next ground in emery stones and then pumped into four storage tanks where the examination and correction of the slurry takes place. Each tank will contain seven hours' run, and any one can be drawn on as desired. A floor pit connected with each tank next receives the slurry, and from this pit it is pumped to the kilns, of which there are four, two being sixty and two sixty-five feet long. The clinker drops into pits beneath the floor, is elevated to a Mosser cooler and passes by conveyor to the grinding room. This room is supplied with one Krupp ball mill and two Gates' tube mills. A screw conveyor and elevator belt transfer the finished cement to the stock room, where packing is done. The coal grinding plant consists of a rotary drier and a tube mill.

A 650-h. p. Goldie and McCulloch Wheelock tandem condensing engine, and a 100-h. p. "Ideal" furnish the necessary power for operations of plant and lifting respectively.

The marl is obtained at lake McNab in the township of Keppel, on the Harriston and Owen Sound branch of the Grand Trunk railway, some twelve miles from the works. A private spur was constructed to the lake from a point two miles distant. This marl area comprises 460 acres running from fourteen to twenty-five feet in depth. A steam shovel is employed to raise the marl.

Clay is obtained from the village of Brookholm in the township of Sarawak, at a distance of only one mile from the plant. The capacity of the works is 350 barrels holm per day. "Sun" cement is marketed largely in Western Ontario and Western Canada.

Shipping facilities for the export of the finished product and the importation of coal by water are particularly good. The company has its own docks and coal derricks adjacent to the mill. Coal is imported by water direct from Cleveland.

"Sun" cement was first made in 1902. Then the dry process was used, but this proving unsatisfactory, owing to the tendency of the clay to "ball" in masses, the wet process was introduced. Manufacturing by this method was begun in July, 1904.

The Sun Portland Cement Co. A corner in the assaying laboratory.

The Superior Portland Cement Company

President	B. E. McKenzie, M. D.
Vice-Presidents	Thos. McCarty and W. Howard Jackson.
Secretary-Treasurer	Geo. McIntyre, Orangeville.
Authorized capital	$500,000.
Works	Orangeville, Ont.
Brand	"Superior."

Three hundred and sixty acres of marl in the township of Caledon, Peel county, from twelve to thirty feet in depth and one hundred acres of clay in the township of Garafraxa, of an average depth of eight feet, will give some idea of the extent of material available for cement purposes by this company.

The mill stands but a stone's throw from the Canadian Pacific railway station at Orangeville. It is intended to lift the materials by steam shovel, and bring them to the works by railway. The clay will come nine miles by the C. P. R., and the marl on the company's own railroad, a distance of two and five-eighths miles. A layer of two feet of peat overlies the marl deposit.

Prior to passing into large concrete octagonal wash mills, the clay will be put through a disintegrator. It and the marl will then be sent down chutes to the two wash mills as stated, which will be provided with gratings at one side. Through these gratings the mixture will gradually wash and be conducted to an elevator sump, thence to emery mills and a tube mill, which will complete the raw grinding. Three large wooden storage tanks will be provided in which the correction of the mixture will be made. These tanks will be agitated by compressed air.

Foundations for three rotary kilns eighty feet long and seven feet in diameter are already laid, and ultimately the company will install three additional kilns. Clinker pits, one for every two rotaries, will be provided at the discharge ends of the

Superior Portland Cement Company, Orangeville. Main building.

kilns. Elevators will convey from these pits to the rotary coolers. Two ball mills and two tube mills will easily handle the immediate output of the kilns, but another ball mill and an extra tube mill will have to be added when the complete battery of six kilns is in operation. Griffin mills will probably be employed to grind the coal.

The mixing, burning and grinding building is two hundred and ninety-seven by eighty feet. The coal house is one hundred and six by forty-three feet, and the stock house one hundred by seventy-five. In addition, there is a power house which will be supplied with engines capable of generating one thousand horse power. Electrical generator and motors for individual driving will be features of the equipment. The tracks at the works will be elevated twelve feet on a trestle, so that the materials and coal can be dumped from the cars directly into the works. The capacity of the completed plant will be six hundred barrels of cement per day. The company expect to have their brand on the market during the coming summer.

There is a possibility that in the early future the Cataract water power on the Credit river may be employed to generate energy which can be transmitted by wire to the works at Orangeville. It is said that the falls in the river gorge at the place referred to afford a head of nearly two hundred feet.

The Western Ontario Portland Cement Company

President ....A. S. Langrill, M. D.
Secretary-Treasurer .... J. A. Mitchell, Atwood, Ont.
Manager .... M. M. Hiles.
Authorized capital .... $500,000.
Works ....Atwood, Ont.

This company was incorporated under Provincial charter in the summer of 1903 and proposes to manufacture Portland cement from clay and marl, both of which are found convenient to the village of Atwood, in deposits of considerable extent. The marl will be obtained five miles south of the village, the site of the plant, in the township of Elma, from an ancient lake bottom now a marsh. The area is 250 acres. There is an overlying layer of peat from two to five feet in thickness, which the company hopes ultimately to utilize as a source of fuel. The installation of suitable drying and compacting machinery is a part of the general scheme, and in view of recent improvements in peat fuel manufacture, the possibility of success will be granted. The marl underneath this peat growth is from eighteen inches to twelve feet in thickness, and analyses show this to be of very good quality. Beneath the marl in turn is found the clay running to a depth of thirty feet.

A second area of equal extent is also held by the company. This deposit lies five miles west of the site of the works in the townships of Grey and Elma. This, however, will probably not be worked for some time, as the first mentioned beds will supply enough raw materials for many years at the estimated output.

The process will be the wet slurry method, and for this suitable mill buildings are being erected and plant installed. Six rotaries are to be employed with an estimated capacity of six hundred barrels of cement per day.

The clay and marl are to be raised by steam shovel, and will be transported to the works over a standard gauge track for which the steel was supplied by the Grand Trunk Railway Company. The company will have the option of buying this road outright at the end of ten years. It is expected that the town of Atwood will assist the enterprise by granting a free mill site and exemption from taxes for a period of 20 years. The company expect to have their product on the market in October of this year.

NATURAL CEMENT

Natural cement, as stated elsewhere, is produced by burning an impure limestone. In Ontario, it is found in certain parts of the Trenton and Niagara formations.

An analysis reveals the presence of lime, magnesia and clay in more or less definite proportions. In nearly all natural cement quarries, the stone appears in strata. Analyses almost invariably show that the composition of the rock varies with the depth, the tendency being for the calcium carbonate to be in maximum proportion at the upper stratum, and the clay ingredients a maximum at the lower. Let us suppose a case where there is an excess of the lime constituent in the upper layers and an excess of clay in the lower, the mean of both giving about the correct proportion for a good cement. Now if rock be taken indiscriminately from the quarry, burnt and ground, it will be seen that an analysis would no doubt indicate that the two ingredients were present in about the correct proportions, while it would be equally true that evidences of both over-claying and over-liming might be detected in the

finished product. The thorough mixing would be accomplished in the grinding, yet it would be impossible that the clay and lime of adjacent fragments in the kiln could unite chemically in a way essential to a good cement. The difficulty in securing a constant and intimate mixture is one respect in which the natural cement is less likely to develop the strength for which good Portland has acquired a reputation.

Both natural and Portland cements have their uses, and the answer as to which is desirable in any instance will depend on the strength required, on the allowable time for setting, on whether or not the cement is to be laid under water, and on the cost. If no great strength is required, and a rapid setting mortar is desirable, natural cement can be employed at a less cost than Portland. The time of setting, however, is exceedingly variable in both natural and Portland cements. The former usually begins to set in five to forty minutes, and attains its permanent set in twenty minutes to two and a half hours. Portland, on the other hand, begins to set in three-fourths of an hour to three hours, and attains its final set in two and a half to eight hours.

The question of relative cost is worthy of a little consideration, and the following is given for the purpose of comparing in a typical case, the cost of two mortars intended to give the same strength.

Suppose a cement mortar for foundations, piers or walls is required which will develop say 200 pounds per square inch ultimate tensile strength in three months. Most Portland cement mortars mixed in the proportion of one of cement to five of sand by volume, will attain this strength in the time stated, while a natural cement mortar for the same specification would require to be mixed in about the ratio of one of cement to two of sand. Let us assume the price of sand to be about $1,25 per cubic yard, that of natural cement to be $0.90 per barrel, and that of Portland to be $2.50 per barrel. In explanation, it should be said that the voids in the sand and its shrinkage on the addition of water will render the volume of the resulting mortar very little in excess of that of the sand as first measured. In both cases following, the mass of mortar would in an average case be about one cubic yard.

Portland Cement Mortar 1 : 5		Natural Cement Mortar 1 : 2	
.9 cubic yards sand........@ $1.25 =	$1.12	.8 cubic yards sand........@ $1.25 =	$1.00
1.2 bbls. cement............@ 2.50 =	3.00	2.5 bbls. cement............@ 90 =	2.25
Cost per cubic yard	$4.12	Cost per cubic yard	$3 25

It is thus seen that the natural cement mortar is 87 cents cheaper per cubic yard than a Portland cement mortar of anticipated equivalent strength. This conclusion of course obtains only under the conditions assumed. The relative cost would be influenced by a variation in the cost of the two cements and of the sand, by the quantity of water used, and by the voids in the sand. Our Ontario natural cements are slow-setting, and of course none of them develop the early tensile strength either neat or in mortar of the Portlands.

The producers of natural cement in Ontario are Isaac Usher & Sons, Queenston, the Estate of John Battle, Thorold; F. Schwendiman, Hamilton; and the Toronto Lime Company, Limehouse.

Queenston Cement Works

The Queenston Cement Works are situated in the township of Niagara on the Queenston and Grimsby stone road. They are but two miles from the historic village of Queenston, made famous nearly a century ago through the heroic exploits of Sir Isaac Brock, Laura Secord and others in the defense of Canada.

The plant stands on a sheer precipice one hundred and eighty-five feet in height. The well-known "Queenston blue" Niagara limestone used extensively for building purposes is here 22 feet deep. Beneath it is found the cement rock 6 or 7 feet in

thickness, and beneath this in turn is a gray sandstone. Mr. Usher is the lessee of a property somewhat exceeding 450 acres, only 15 of which have been mined.

Drifting was begun from the base of the old limestone quarry, from which a great deal of the material for the masonry in the first Welland canal was obtained. The cement rock is quarried with the assistance of steam and air rock-drills and explosives. A track has been laid and by means of cars the stone is hauled to the feeding hoppers of the kilns, which are on a slightly lower level than the bottom of the cement rock stratum. Pillars of rock are left at intervals of about 30 feet to support the limestone overhead. No timbering has been found necessary, and in twenty years, no accident to any workman has occurred. The mine has perfect ventilation.

There are eight upright masonry continuous draw-kilns, each thirty-two feet in height and eight feet in diameter. They are fed from above with alternate layers of stone and coal, and at any time there are about twelve feet of fire in a kiln. The lower portion is styled the cooler and the upper the forewarmer. A cord of cement stone makes twenty-two barrels of cement.

The coal is delivered from a switch on the Grand Trunk railway, and is dumped on the same level as the firing hopper of the kilns. A kiln is drawn four times in twenty-four hours. Experienced men sort the burnt stone, and any parts not sufficiently burned are returned to the kilns. The properly calcined stone passes down a chute to the "cracker" and from there to a steel-plate grinder, in which it is reduced to the size of wheat. Buhr stones or Sophia mill stones complete the grinding. A gravity screen here rejects any portions incompletely ground and returns them to the stones, but whatever is sufficiently reduced goes down another level to the store room. It is thus seen that gravity assists very considerably in the handling of the material. A spur of the Niagara branch of the Michigan Central railway runs between the packing and store houses, so that shipping by rail is rendered extremely convenient.

The output of the plant is at present 350 barrels per day, and additions and improvements, especially in the quarrying and grinding, are soon to be made.

"Queenston" cement is employed chiefly for floors, foundations, silos, dwellings and farm use generally, and is marketed in Western Ontario and Manitoba. A small export is annually made to Lewiston and other towns in the vicinity, in New York state.

The Estate of John Battle

The works of this company are in the town of Thorold. In 1841 Mr. John Brown, the predecessor of the late John Battle, opened the quarries from which the cement rock is now obtained. There is a surface layer of fourteen feet of clay overlying an equal thickness of crystalline limestone. Beneath this is found the cement stone, varying in thickness from eight to ten feet, and of tolerably uniform quality. The stone is mined both in the open cut and in drifts underneath the overlying limestone, the roof being supported as in the Queenston mine on pillars of either the stone itself or of built-up materials. The location has an area of 50 acres.

From the quarries, the rock is brought by narrow gauge track and horse cars to a battery of five upright continuous kilns, where the burning is done by filling alternate layers of soft coal and stone. Four days after the fire is begun, "drawing off" is commenced, and is repeated at intervals of twenty-four hours continuously afterwards. The usual care in the selection of proprely burned rock and the rejection of cinder, slag and underburned stone is then necessary. The calcined stone is brought by the Niagara, St. Catharines and Toronto Electric Railway to the mills in the town of Thorold, one mile from the kilns, power for the purpose being obtained from the old canal, where a head of fourteen feet is available. Two turbines of eighty and sixty horse power respectively, supply the necessary energy.

The stone is first broken in a "cracker," and then ground in buhr stones of which the mill has three run. Bagging in cotton and paper is done from spouts connected with the receiving bins. The output of "Thorold" cement is 200 barrels per day, and

reaches about thirty thousand barrels per year. The present proprietors are the sons of the late John Battle, who assumed control of the works at least thirty years ago.

F. Schwendiman

The quarry from which Mr. Schwendiman obtains his cement rock is situated in the township of Barton, four miles from Hamilton. The rock at present is being obtained from the valley of a small stream. It is burned in a continuous fire-brick lined upright kiln, and reduced by a "cracker" of the coffee mill type, and by buhr stones, of which the mill has two run. The kiln has a vertical height exceeding 20 feet and a maximum diameter of about eight feet. The stone is carted up an incline to the top of the kiln where a receiving hopper has been constructed. The throat of the kiln is just below the hopper, and is about five feet in diameter. The firing is done in two burning arches on opposite sides of the kiln. These arches are about six feet in length—the thickness of the walls of the structure. Soft coal is the fuel employed. The burned stone is drawn off beneath through an inclined chute and is wheeled by barrows to the grinding mill. The plant has a capacity of 65 barrels per day. It is marketed from Rymal station, a short distance from the quarry.

Toronto Lime Company

The Limehouse cement works are situated on the main line of the Grand Trunk railway, where the road makes the ascent of the Niagara escarpment. The formation is the same as at Thorold, being at the base of the Niagara limestone.

The Toronto Lime Co., Limehouse. View of kiln for making natural cement.

The company manufactures lime extensively, this industry of late years much surpassing in importance the manufacture of natural cement. The Gowdy kilns in which the cement is made are situated at Limehouse. The limestone has been quarried from the surface for building and for the manufacture of lime over an area of twelve acres. Under this to a thickness of nine feet lies the cement rock. The location covers an area of nearly forty acres. On account of the well marked stratification, the quarrying is attended by no great difficulties.

The kiln is similar in construction to the one at Hamilton just described. The height over all is thirty-five feet, the throat at the top being eight by ten feet. There are four fire holes, two on each side of two opposite sides, into which the stoking is done. The "Eldridge" system of blowing is employed. A rotary fan draws hot gases from a point seven feet below the top of the kiln, and this hot air is forced by the same fan into the fire-place. By a suitable contrivance any quantity of cold air may be admitted to the blast to mix with the hot. The manager states that the most desirable fuel for the calcination of natural cement limestone, is wood. Coal is said to give too intense a heat, and the object of the Eldridge system is to moderate this heat by the introduction of carbonic acid gas into the blast. The method is said to work very satisfactorily. The kiln is lined with fire-brick, and this lining has to be renewed once every three years.

The kiln is drawn once every four hours, and the stone allowed to cool an hour on the floor before being removed by cart to the mill to be ground. The "cracker" reduces to pea size, after which the buhr stones complete the reduction. The capacity of the plant is 100 barrels per day. Packing is done in barrels of 240 pounds capacity, and in bags of half that quantity. The brand is known as "Ontario."

TESTING OF CEMENTS

A perfect method of testing cement has yet to devised. A uniform method—or rather a method which with uniform material will give uniform results in the hands of all experienced operators—has also yet to be invented. Many attempts to secure such results by complicated and expensive testing machines have been made, and in some cases at least the results obtained were less satisfactory than where the simpler method was used. It should be and is possible to employ a few simple tests—requiring but inexpensive equipment and reasonably sure in results, that will discover a good cement and expose the pernicious qualities in a bad one. For the general user, this should be sufficient. The tests that are usually made are six in number, and are as follows: fineness of grinding, specific gravity, tensile strength, neat and with sand, the hot test and the time of setting.

Fineness of Grinding

It has been observed that fine grinding will decrease the tensile strength neat, but will increase it in a mortar. As no cements are used commercially without some kind of aggregate, the latter is the phase of the result to which the user's attention is directed. Fineness is not a sure indication of the value of a cement, although all cements are improved by fine grinding. The residue on sieves of various sized mesh, usually fifty, one hundred and two hundred to the lineal inch, is expressed as a percentage of the original weight. In the results printed elsewhere, one thousand units by weight of cement were sifted by hand. Sifting was discontinued when after a certain time interval a quantity less than one unit—one-tenth of one per cent.—passed the sieve. Sieves of fifty and one hundred meshes to the linear inch were employed in this instance. A "trace" may be interpreted as a quantity less than one-tenth of one per cent. of the original.

Specific Gravity

The specific gravity test is considered to be a means of detecting under-burning, over-burning or adulteration. Cement being a powder susceptible to the action of water, coal oil or turpentine is usually employed in the determination. Care should

be taken that no change of temperature in the fluid takes place during the experiment, and that no bubbles of air are concealed in the flask. An overburned fused clinker will give a heavy cement, while an underburned one is likely to be low in specific gravity. Adulterants are usually of less density than cements, and will operate to reduce the specific gravity.

Tensile Strength

The tensile strength test, rightly or wrongly, has come to be the one to which the popular eye is directed in judging the merits of a brand of cement. This test, if properly made, is without doubt a valuable though not a perfect indication of quality. The cement is made into a stiff batter and placed in briquette moulds of a least cross-section of one square inch. After setting for twenty-four hours in moist air, the briquettes are removed from the moulds and placed in a water bath where they remain for times varying very much at the caprice of the tester. These periods, however, are usually three days, seven days, twenty-eight days, and three, six, or twelve months. At the end of the interval desired, they are broken in some kind of tensile testing machine. A good cement should show an increasing tensile strength as the ages become greater. If there is a dropping off in ultimate strength at the longer time tests, it would lead us to suspect that under-burning or over-liming was the fault. Either of these will give what we have come to call "free lime." This "free lime" through spontaneous disintegration, will in time reduce the tensile strength.

In the experiments, whose results are given elsewhere, the percentage of water necessary to give a proper consistency was found in each instance by a preliminary test. That percentage, when learned, was used in the subsequent tests with that brand. The water used was first brought to roo mtemperature (608 F.) and a regular interval of three minutes' trowelling on the slab was given each batter before placing in the moulds.

Experience has shown that the ratio of compressive to tensile strength varies from seven to ten in mortar in the proportion of one of cement to three of sand, and as the latter is much more easily obtained, it is almost exclusively employed, notwithstanding the fact that cement in sructures is not usually subjected to tensile stress. Experience has further shown that the personal element is a matter of great consequence in the making of tensile tests of cement. This is true to a very great extent in mortar tests, and in a lesser degree with neat cement also. The manner and duration of the mixing and the method of compacting in the mould would undoubtedly influence the results obtained in no small degree. For this reason it is scarcely fair to compare one man's results with another's, or perhaps even with his own, unless through extensive experience he has acquired a method of working that is nearly uniform. Were we to take a parcel of cement thoroughly mixed so that the quality is uniform throughout, and divide it into five parts, giving each of five experienced testers a sample, with instructions to determine the tensile strength of a three to one mortar, we would very probably be surprised at the discrepancy in results. The so-called "personal equation" must be reckoned with when an attempt is made to institute comparisons.

The mortar tests were made from a three to one mixture for Portlands, and a one to one for natural cements. The sand used was a calcareous pit variety, free from organic matter, loam or clay. The briquettes were lightly rammed with a steel rammer, and every attempt to do this in a uniform manner was made. The proportions were by weight, not volume.

Constancy of Volume

It has become the fashion to consider the hot test, a test for free lime, which in the presence of heat and moisture slacks and disintegrates the pat. This may or may not be so, but it is certain that free lime, if added to a good cement, will produce the "blowing" which it is the purpose of the hot test to detect. In the test of Ontario brands, the pats were allowed to stand six hours in moist air above a

bath of water kept at 120° F. Then they were put in the hot bath for the remaining eighteen of the twenty-four hours. Pats made of good cement should not leave the glass plate, should not crack or disintegrate in any way, and if broken should snap with a moderately high musical note. A cement that stands the hot test and is finely ground, is not likely to give very much trouble.

Setting

The setting is usually reported at two stages — initial and final. Initial set is defined as the interval elapsing from the time of adding the water to the cement until the batter will support a needle of diameter equal to one-twelfth of an inch and weighted with a quarter of a pound. The final set is the time elapsing from the addition of the water until the batter will support a needle of one twenty-fourth inch diameter weighted with one pound. As the time of setting will depend on the amount of water used, that quantity which with trowelling will first cause a gloss to appear on the surface of the batter is recommended. In other words, a minimum of water is to be employed.

The specifications, for standard Portland cement, of the Canadian Society of Civil Engineers, and of the American Society for Testing Materials, are appended:

The Canadian Standard

The standard specifications of the Canadian Society of Civil Engineers are as follows:

The whole of the cement is to be well-burned pure Portland cement, of the best quality, free from free-lime, slag, dust, or other foreign material.

(1) *Fineness*: The cement shall be ground so fine that residue on a sieve of 10,000 meshes to the square inch shall not exceed 10 per cent. of the whole by weight, and the whole of the cement shall pass a sieve of 2,500 meshes to the square inch.

(2) *Specific Gravity*: The specific gravity of the cement shall be at least 3.09, and shall not exceed 3.25 for fresh cement; the term "fresh" being understood to apply to such cements as are not more than two months old.

(3) *Tests*: The cement shall be subjected to the following tests:

(a) Blowing Test: Mortar tests of neat cement, thoroughly worked, shall be trowelled upon carefully cleaned 5-inch by 2½-inch ground glass plates. The pats shall be about ½-inch thick in the centre, and worked off to sharp edges at the four sides. They shall be covered with a damp cloth and allowed to remain in the air until set, after which they shall be placed in vapor in a tank, in which the water is heated to a temperature of 130° F. After remaining in the vapor six hours, including the time of setting in air, they shall be immersed in the hot water and allowed to remain there for eighteen hours. After removal from the water the samples shall not be curled up, shall not have fine hair cracks, nor large expansion cracks, nor shall they be distorted. If separated from the glass, the samples shall break with a sharp, crisp ring.

(b) Tensile Test, Neat Cement: Briquettes made of neat cement, mixed with about 20 per cent. of water by weight, after remaining one day in air, in a moist atmosphere, shall be immersed in water, and shall be capable of sustaining a tensile stress of 250 lb. per square inch, after submersion for two days; 400 lb. per square inch after submersion for six days; 500 lb. per square inch after submersion for 27 days. The tensile test shall be considered as the average of the strength of five briquetttes, and any cement showing a decrease in tensile strength on or before the twenty-eighth day shall be rejected.

Sand and Cement: The sand for standard tests shall be clean quartz, crushed so that the whole shall pass through a sieve of 400 meshes per square inch, but shall be retained on a sieve of 900 meshes per square inch. The sand and cement shall be thoroughly mixed dry, and then about 10 per cent. of their weight of water shall be

added, when the briquettes are to be formed in suitable moulds. After remaining in a damp chamber for 24 hours, the briquettes shall be immersed in water, and briquettes made in the proportion of one of cement to three of sand by weight, shall bear a tensile stress of 125 lb. per square inch after submersion for six days, and 200 lb. per square inch after submersion for 28 days. Sand and cement briquettes shall not show a decrease in tensile strength at the end of 28 days or subsequently.

(4) The manufacturer shall, if required, supply chemical analyses of the cement.

(5) *Packing*: The cement shall be packed either in stout air and water-tight casks, carefully lined with strong brown paper, or in strong air and water-tights bags.

(6) The manufacturer shall give a certificate with each shipment of cement, stating (1) the date of manufacture; (2) the tests and analyses which have been obtained for the cement in question at the manufacturer's laboratory; (3) that the cement does not contain any adulteration.

The American Standard

The standard of the American Society for Testing Materials is as follows:

Definition. The term Portland cement is applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than three per cent. has been made subsequent to calcination.

Specific Gravity. The specific gravity of the cement, thoroughly dried at 100° C. (boiling point) shall not be less than 3.10.

Fineness. It shall have by weight a residue of not more than eight per cent. on a No. 100 sieve, and not more than twenty-five per cent. on a No. 200 sieve.

Time of Setting. It shall develop initial set in not less than thirty minutes, but must develop hard set in not less than one hour nor more than ten hours.

Tensile Strength. The minimum requirements for tensile strength for briquettes one inch square in section shall be within the following limits, and shall show no retrogression in strength within the periods stated.

Neat Cement

24 hours in moist air	150 to 200 lb.
24 hours in moist air and 6 days in water	450 to 550 lb.
24 hours in moist air and 27 days in water	550 to 650 lb.

One part cement to three parts sand:

24 hours in moist air and 6 days in water	150 to 200 lb.
24 hours in moist air and 27 days in water	200 to 300 lb.

Constancy of Volume. Pats of neat cement about three inches in diameter one-half inch thick at the centre and tapering to a thin edge shall be kept in moist air for a period of twenty-four hours.

(a) A pat is then kept in air at normal temperature and observed at intervals for at least twenty-eight days.

(b) Another pat is kept in water maintained as near seventy degrees F. as practicable, and observed at intervals for at least twenty-eight days.

(c) A third pat is exposed in any convenient way in an atmosphere of steam above boiling water, in a loosely closed vessel for five hours.

These pats to satisfactorily pass the requirements shall remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

Sulphuric Acid and Magnesia. The cement shall not contain more than 1.75 per cent. of anhydrous sulphuric acid (SO_3) nor more than 4 per cent. of magnesia (MgO).

USES OF CEMENT

In general, cement for construction purposes is employed in two ways, namely, in mortar and in concrete, either plain or reinforced with metal. It is almost never used commercially neat, that is, without sand. Sometimes, however, for grouting masonry, the neat paste is employed, experience having proved that there are almost uncontrollable tendencies on the part of the sand in a grouting mortar to separate from the cement, to choke passages, and to cause voids to occur.

Experiments in the use of cement as a protection to bridge steel in structures have proved its usefulness. Structural steel exposed to the gases of passing locomotives for example, shows a rapid and harmful corroding, which a paste of cement, red lead and japan has proved very efficacious in arresting. It is the custom to apply this paste in a thickness of one-quarter of an inch. Further experiments will no doubt confirm the finding of those who have tried this preventive to corrosion. These uses and some others, for example the utilization of cement as a pigment in paint, must be regarded as special.

For Making Mortar

The use of mortar is exceedingly ancient. Lime mortar has been employed in the masonry of southern Europe, particularly in Italy, for twenty centuries, but in its durability, its strength and the variety of uses to which it may be put, it is quite inferior to its more modern rival, Portland cement mortar. It is generally believed that the ultimate hardening of lime mortar is due to the absorption from the air of carbonic acid gas, which in combination with the lime forms a limestone. Hence it follows that lime mortar which has been thoroughly exposed to the atmosphere for a sufficiently long time will approach more or less in chemical composition and hardness the common limestone with which all are familiar.

Lime versus Cement

Analyses made of lime mortars taken from the structures of antiquity demonstrate, however, the following: the mortar is never completely changed to the carbonate of lime except at the surface, and where mortars have been excluded from all air, no change even after the lapse of centuries has taken place. The great time necessary to accomplish the complete hardening of lime mortars is a serious objection to their use in many cases. The structure in which they have been used may, due to settling of foundations or to the weight of material above it, deform seriously before it has developed a sufficient hardness to ensure safety. Again, the evolution of the modern tall building has rendered necessary a radical change. Lime mortar is many times weaker in compressive strength than is a mortar of similar mixture containing Portland cement, the latter of which will in time equal clay brick in compressive strength. Lime mortar of a mixture three to one at the age of a year will average a tensile strength of 50 lb. per square inch, or a compressive strength approaching 500 lb. per square inch. Cement mortar, three to one of the same age, will give a tensile strength of 400 lb. per square inch, and a compressive strength approaching 4,000 lb. or about the strength of a good clay brick, as said above. In other words, the strength of cement mortar is approximately eight times that of lime mortar of the same mixture and age.

Results of tests made under the direction of Prof. C. H. C. Wright, of the School of Practical Science, Toronto, on brick piers using lime mortar of certain proportions in one series, and cement mortar in another are given below. The bricks, age and

other conditions being as nearly identical as possible, we see that the latter are capable of resisting from two to four times as great a load per unit of area.

Description of Pier.	Crushing Strength.			
	Lime mortar, 2 to 1.		Cement mortar, 3 to 1.	
	lb. per sq. in.	tons. per sq. ft.	lb. per sq. in.	tons. per sq. ft.
Humber Brick, 2nd class, 8 courses	293	21	1,131	81.4
Carleton Clinker, 8 courses	609	43.8	2,408	173.4
Yorkville Brick No. 1, white	509	36.6	1,062	76.5
Yorkville Brick, No. 2, 8 courses	392	28.2	1,018	73.3

The inconsistency of laying good clay brick in lime mortar where the structure is to be subjected to heavy loading, lies in the manifest inequality in point of strength of the bricks and their jointing. Further, the fact that lime mortar cannot be laid in water, and will not harden under water, renders it useless for all kinds of hydraulic and submarine work. So, too, its porosity, especially in damp and frosty situations puts another limitation on its use as a material of construction.

What Mortar Is

A mortar is made by thoroughly mixing sand, cement and water in varying proportions. Of sand there are many kinds differing in composition, angularly, size of grains, etc. Experience seems to prove that a limestone or calcareous sand is generally to be preferred to a silica or quartz sand, there being usually a better bond between the cement and the grains in the case of the former.

For submerged or impervious work solid mortar is necessary, and for almost all uses it is desirable. A solid mortar is obtained by having a quantity of cement equal to or slightly in excess of the voids in the said, there being usually a better bond between film of cement completely or almost completely surrounding it. It will be agreed that a sand whose grains are of uniform size will have a greater percentage of voids than will a sand with grains of varying size. Hence it follows that the latter will require a less quantity of cement to produce a solid or impervious mortar. The eight thousand grains contained in one cubic inch of sand, each grain being one-twentieth of an inch in diameter, present an external area of one hundred and twenty square inches against one hundred and seventy-six square inches where the grains are one-thirtieth of an inch in diameter. From this it is seen that the "covering power" of cement will be greater in a coarse sand; or what is probably the same thing, for equal strengths, more cement will be needed with a fine variety, solidity not being an essential. Again, for the same proportions of ingredients in mortar, greater strength will be obtained with a coarse sand than with a fine one.

Sand for Mortar

The question of voids in a sand where a solid and impervious mortar is desired is important. The percentage of voids in any case may be easily obtained by adding water to the sand in a water tight vessel until it flushes even with the surface of the sand. The increase in weight due to the added water, converted into units of volume and expressed as a percentage of the volume of the sand, is the process in brief.

Voids in sands vary from tweny-five to fifty per cent., or from a quarter to a half of the wetted volume which is on an average, twenty per cent. less than the volume when dry. It should be remembered, too, that a shrinkage in the cement on the

addition of water may be put at ten per cent. Suppose we desire a solid mortar from a sand with thirty-five per cent. of voids. It is evident that a three to one mixture will give this with a small margin, since the voids would be $^{35}/_{100}$ of $(3 \times {}^{80}/_{100}) = .84$ and the cement available to fill these voids would be $^{90}/_{100}$ of $1 = .90$.

The essentials of a good sand are usually stated in specifications to be cleanness, coarseness and sharpness. The cleanness is understood to be freedom from loam, clay or organic matter, and the sharpness as synonymous with angularity. A number of tests for the purpose of discovering the effect of clay in a three to one mortar were made last fall in the cement laboratory of the School of Practical Science. The percentage of clay varied from two to six per cent, the other elements being constant. It will be seen from the following summary that in all cases the effect of the clay was to increase the tensile strength. It would appear then as if small percentages of this material are not objectionable in a cement mortar.

Age, 28 days.	
Per cent. of clay.	Average tensile strength.
0	209
2	248
4	223
6	233

The effect of adding sand to a cement is to weaken it, no mortar being as strong as a neat cement. The following table is given as representing the relative strengths in the average case.

Mixture.		Relative Strength.
Cement.	Sand.	
1	0	1
1	1	⅔
1	2	½
1	3	⅓
1	4	¼

The Use of Lime Paste

The practice of adding lime paste to cement mortar for plastering and other purposes is quite common, the objects sought being cheapness, strength, imperviousness and a desire to attain a smoothness in working not possible with cement alone. Investigation seems to prove that an addition of lime paste not exceeding twenty per cent. of the mortar will not reduce the strength, and in some cases appears to increase it. While slightly reducing the cost, it gives the mortar a "body" very much desired by the workmen. Beyond the limit given, it is perhaps not wise to go if strength is a factor sought.

The Owen Sound Portland Cement Company, in their brochure on the uses of cement suggest the following: "If it is desired to make water-tight mortar for cisterns and reservoirs, and where absolutely water-tight work is required, the following proportions are recommended:

Portland cement.	Sand.	Lime paste.
1 part	2 parts	½ part
1 part	3 parts	1 part

For brick work, Samson Portland cement, mixed with nine parts of sand and one part of lime paste is recommended, although the cheaper proportion of one part of cement, eight of sand, and one and a half of lime paste will give excellent results."

For Impervious Mortar

With the object of determining the causes and remedies for permeability of cement by water, a series of experiments was conductd in 1901 and 1902 in the State University, Columbus, Ohio. In view of the fact that cement is being employed extensively where it is subjected to hydraulic pressure, as in sewers, watermains and reservoirs, a summary of the finding may be interesting. It is as follows:

"The permeability cannot be materially reduced by the application of soap and alum solutions or by finely powdered loam used in the sand, but it can be reduced (1) by the application of one to five coats of cement grout, the reduction amounting to from seventy to ninety-eight per cent. of the initial leakage; (2) by a coating of neat cement mortar one quarter of an inch thick; (3) by the mortar surface standing under a head of water containing suspended matter."

The mixing of the sand and cement should be thoroughly done dry until the color is uniform. Then the water should be added and the whole mass turned over until every part is thoroughly wetted. It is as possible to weaken a mortar by too much water as it is by too little. The correct quantity depends on the size and dryness of the sand, and to some extent on the kind and age of the cement.

The following table is taken from a circular issued by the Buckeye Portland Cement Company of Harper, Ohio, and gives the amount of cement, sand and lime paste needed to lay one thousand bricks.

Mortar in all cases 6 : 1 : 1.

Joint.	Proportion of mortar to brick.	Bus. of sand.	Bbls. of cement.	Bus. of lime.
⅛ in.	1 to 9	3.8	.21	.64
¼ "	1 " 4	9.6	.53	1.6
⅜ "	3 " 10	12.5	.70	2.1
½ "	1 " 3	15.2	.83	2.5

For Making Concrete

The second use of cement is in concrete. Concrete consists of a "matrix" and an "aggregate." The matrix is defined as the cement and the sand plus the water. The aggregate may be broken stone, shingle, cinders, slag, etc. The remarks *re* solid and impervious mortar will apply also to a solid and impervious concrete. For a solid concrete the voids in the aggregate should be filled with the mortar, which in turn should contain sufficient cement to fill all cavities in the sand. It should, however, be stated that very good and serviceable concrete may be obtained where no attempt is made to procure a solid mass. The quantity of voids in an aggregate depends on the uniformity or lack of uniformity in size and shape of the individual parts. To reduce this quantity, it is evident that there should not be uniformity of size. The voids in an aggregate will vary from twenty-five to fifty per cent.

Suppose it is desired to produce a solid concrete knowing the voids to be as follows: sand, 35 per cent., aggregate, 40 per cent. We know from the previous discussion that a three to one mixture will give a solid mortar, remembering that sand and cement shrink twenty and ten per cent. respectively on the addition of water. The volume of this mortar will probably be about equal to that of the wetted sand, or $^{80}/_{100}$ of $3 = 2.4$ volumes. These 2.4 volumes would by a simple calculation be the voids in six volumes of aggregate of the character assumed. This means then, that a 1:3:6 mixture will secure the solidity desired.

Gravel and water-worn shingle are often employed as an aggregate in rough work. Their value will much depend on their freedom from loamy and other earthy matters, but their lack of angularity is an objection. This affects the strength of the concrete, the bond between the cement and the aggregate being more easily broken where smooth pebbles are used for the latter. This bond is doubtless strongest where

the aggregate is crushed limestone. Cinders and slag have the advantage of being light though lacking the strength of the stone. The weight of limestone concrete is about 150 pounds per cubic foot, while that of cinder concrete is about 100 pounds. For flooring purposes and where resistance to fire and economy are considerations, this latter commends itself.

The process of mixing should be thorough. The sand and cement should be mixed dry, after which the stone should be added, and all thoroughly mixed again. The addition of the water and a turning over a sufficient number of times to wet the whole mass complete the process of preparation. Thorough ramming until water flushes to the surface will improve the strength of concrete though care should be taken not to prolong the ramming past the point where initial set begins. For the same reason a batch only of such size as can be put in place before setting has begun should be mixed at a time. Where a large quantity of concrete is required, it is more economical to employ some good type of mixing machine. Such a machine should be so designed that the complete dry mixing of the sand and cement can be done before the aggregate and water are added. Machines should be so constructed that the mixing may be continued until a satisfactory and complete incorporation is obtained. In continuous mixers, this is apt not to be provided for.

The Uses of Concrete

Concrete as a material for the construction of all kinds of foundations has to a great extent replaced stone masonry of late years. Its cheapness, and the fact that skilled labor is not required in putting it in place, have undoubtedly been the chief encouragements in its use. For bridge abutments, piers and arches, building foundations, canal locks, walls of dwellings and warehouses, floors, dams and breakwaters, street pavements and sidewalks, etc., concrete has "come to stay."

The character of the mixture used in any case will depend on the strength required. The Hanover Portland Cement Company recommend the following: "According to the importance of the work, the proportions for concrete may be as follows: one part of good Portland cement, three to eight parts of sand, and from seven to fourteen parts of gravel or crushed stone." Cases are on record where a concrete of surprising strength was obtained from a 1:30 mixture, but such lean concretes are not recommended. Indeed, it is no doubt a fact that good brands of cement are sometimes blamed for failures in concrete construction where the leanness of the mixture was wholly at fault.

In work of any considerable magnitude, provision for expansion and contraction due to temperature changes should be made. This provision usually takes the form of "expansion joints" or bulkheads which are merely vertical seams dividing the work into blocks. Partitions of paper or of sand are sometimes employed for this purpose. They should be placed at intervals of thirty to fifty feet.

Concrete and Steel

Until recently, concrete has simply replaced stone in building operations. It has the same mechanical properties, and shares the same defects. Under certain conditions though, it has proved superior to its ancient rival. Within the last generation, new possibilities have opened to concrete through the careful and intelligent addition of steel, the combination bringing into use the good qualities of both materials. "Re-inforced concrete" is a term which of late years has been used to designate this combination. It is also known as "concrete-steel" and as "armoured concrete." It is a well-known fact that the strength of concrete, unlike that of steel or timber, is many times greater in compression than it is in tension. It was probably a recognition of this peculiarity that led to the practice of putting steel in concrete to assist that element of strength which the concrete lacks. In Europe, especially, where its use

has become general, it has been endorsed by the most eminent engineers. In America it is finding new uses monthly, and the increasing cost of wood will tend to render it more popular in the future than it is even in the present day.

Regarding concrete steel, The Engineering Magazine in a recent issue had this to say editorially:

"Among the many advantages of concrete-steel may be mentioned cheapness as compared with other types of massive construction, lightness, economy of space on account of thinness of walls, capacity for carrying heavy loads, ready adaptability to any desired form, speed of construction, fire-proof qualities and safety on a very poor foundation material, since the structure hangs together as a whole and when overloaded does not collapse suddenly, but tends to deform gradually. There are two important respects in which steel construction gains by the addition of concrete. These are protection against rust, and protection against injury by fire."

Re-inforced concrete is the only form of construction that is really permanent. It is not susceptible to atmospheric influences like stone masonry, and when properly built it will not crack like plain concrete. Such cracks lead to ultimate deterioration due to the action of water and frost.

So far as records inform us, the first man to make intelligent application of steel in concrete was W. E. Ward, of Port Chester, N. Y., who erected in 1875 a building in which "not only all the external and internal walls, cornices and towers, were constructed of béton, but all the beams and roofs were exclusively made of the same material re-inforced with light iron beams and rods." Probably the first approximately correct formulae giving the strength of steel and concrete in combination were derived by Julius Mandel in Germany, and by the late Professor J. B. Johnson in America, about the same time.

The indefatigable investigator, Considère of Paris, during the eighties made a series of very valuable contributions to the literature of the subject. The conclusions at which he arrived may be briefly summarized as follows:

1. In armed concrete beams, the concrete on the tension side will submit without rupture to a proportionate distortion of from ten to twenty times that at which it would fail in an unarmed direct tension test. It will also have during the additional period of distortion a strength nearly equal to its maximum strength in direct tension.

2. Several interior stresses are introduced in armed concrete constructions, where rich concrete mixtures are used owing to the shrinkage of the latter during the first eighteen months if exposed to the air, or a corresponding swelling during this period if in submarine work.

3. These interior stresses are to a considerable extent relieved by the slipping of the bars or rods in the concrete, as to which action tests leave no room for doubt. The stress is also relieved in time if cracks are not previously developed by what has been called the tendency of the concrete to eventually yield somewhat to a soliciting force.

The slipping of rods in concrete in which they are imbedded undoubtedly occurs through the weakening of the adhesion between the metal and its surrounding medium, which is very great at first. This weakening is accelerated by vibration and shock to which more or less, all structures are subjected.

Re-inforced Concrete Beams

Last year, a series of tests on re-inforced concrete beams was carried on at the Experiment Station at the University of Illinois. A summary of the conclusions reached may be of interest.

"In beams with the metal re-inforcement small enough in amount not to develop the full compressive strength of the concrete, the maximum load is reached or nearly reached when the metal is stretched to its yield point, and in calculating the resisting moment, the tensional value of the concrete is here negligible and the load at the yield point of the metal may well be considered the full strength of the beam.

So far as strength of the beam is concerned, the load when the steel is stressed to its elastic limit seems the prcper basis for the factor of safety and working load. So far as strength of the beam is concerned, steel having a high elastic limit is advantageous, it being assumed that there is sufficient provision against the slipping of the rods and shearing failures.

*"The determination of the limit of re-inforcement which may properly be used with different mixtures and grades of concrete may best be decided by experiments on beams made to determine this. For the 1:3:6 concrete used, re-inforcement as high as $1\frac{1}{2}$ per cent. for the steel of 33,000 lb. pr square inch elastic limit, and 1 per cent. for steel of 55,000 lb. per square inch elastic limit may be used without developing the full compressive strength of the concrete.

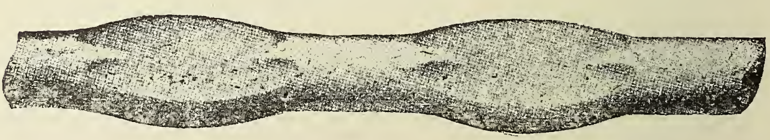
"There was no marked difference in results found for the different forms of re-inforcing bars used."

Systems of Re-inforcement

Re-inforced concrete has found uses whose name is legion, and has led to the evolution of numerous so-called "systems" of re-inforcement. It is regularly employed in the construction of beams and girders, floors and walls, columns, bridge arches, piles, reservoirs, chimneys, lighthouses, sewers, dams, railway ties, fence posts and a number of other purposes too numerous to mention in detail. Most of the so-called systems have features peculiar to themselves, and many of these are undoubtedly meritorious. There is always this, however, that with careless workmanship or lack of intelligent and careful supervision, the best features of any method may be completely nullified. A good system combined with care and intelligence in the application of correct methods will give good results.

Johnson Corrugated Bar.

Ransome Twisted Bar.



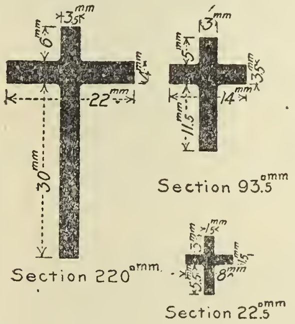
Thacher Rolled Bar. ("Reinforced Concrete" p. 335.)

Thaddeus Hyatt of England investigated the subject of steel and concrete in combination as early as 1876, and the system that still bears his name consists of a series of perforated bars, through the perforations of which pass wires or rods. The whole forms a network of rectangular meshes. It was adapted to such purposes as floor construction.

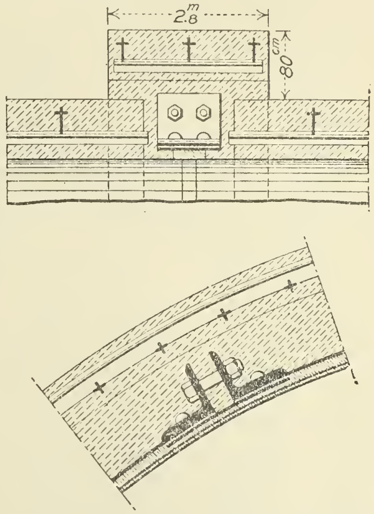
Monier of France attempted the strengthening of concrete by steel about the same time. The Monier system, like the Hyatt, is a network of two series of parallel steel or iron rods which intersect at right angles. Each junction is secured by a wire. The rods are distinguished as "carrying" and as "distributing," according to the purpose they serve. The mesh is from two to four inches to a side.

Ransome employed cold-twisted square rods imbedded near the lower surface of his beams and floor slabs. The cold twisting raises the tensile strength and elastic limit of the metal, and the value of this is pretty generally recognized.

The Bonna system is applied chiefly to the construction of pipes. The steel sections are cross-shaped, and encircle the pipe or sewer spirally or in rings. There are other similarly shaped rods intersecting these and lying parallel to the axis of the pipe line. Concrete completely conceals the steel.



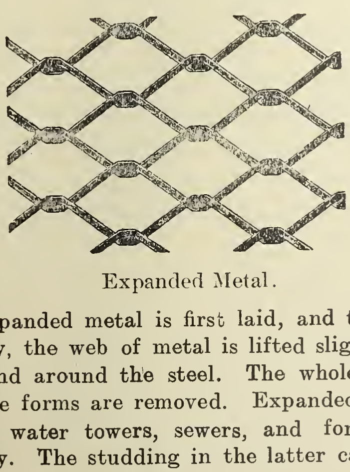
Bonna re-inforcing Bars for cast-pipe sewer.



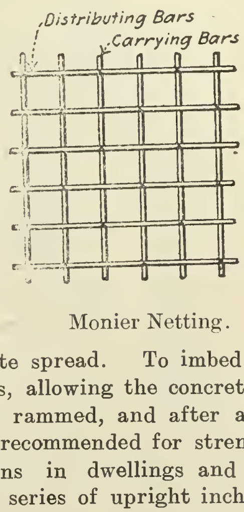
Detail of coupling for cast-pipe sewer. Bonna System.

The Roebling system consists of a woven net of wire stiffened at intervals with parallel steel rods. Webs of this net are sprung in between floor beams or girders, and on this the concrete is deposited. For ceilings, webs of similar netting may be suspended from the lower flanges of the floor beams, the plaster being applied thereto.

Expanded metal has acquired a good and growing patronage. It is a netting of diamond-shaped meshes, which by powerful shearing machines is cut direct from the web of sheet metal. For floor construction especially it has been very favorably received, Temporary wooden forms to support the floor have to be put in place. On



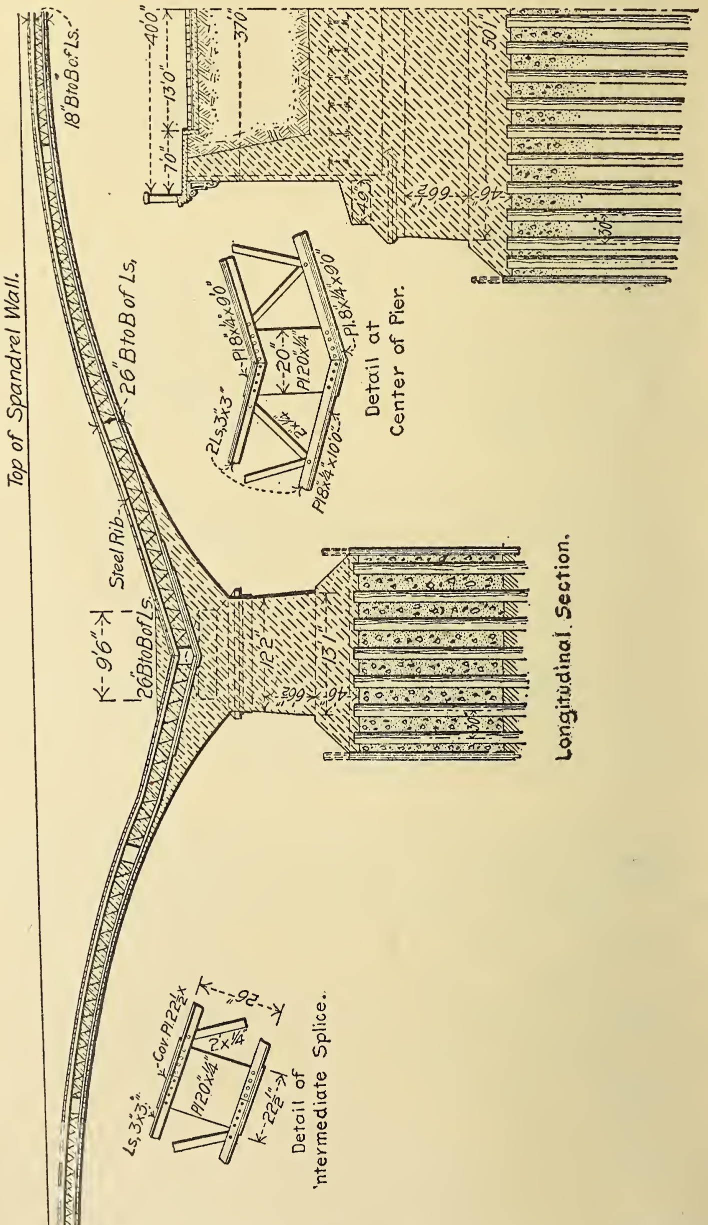
Expanded Metal.



Monier Netting.

these expanded metal is first laid, and then the concrete spread. To imbed the steel perfectly, the web of metal is lifted slightly with hooks, allowing the concrete to pass below and around the steel. The whole is thoroughly rammed, and after a suitable time, the forms are removed. Expanded metal is also recommended for strengthening concrete water towers, sewers, and for thin partitions in dwellings and buildings generally. The studding in the latter case is usually a series of upright inch or inch-and-a-quarter channels.

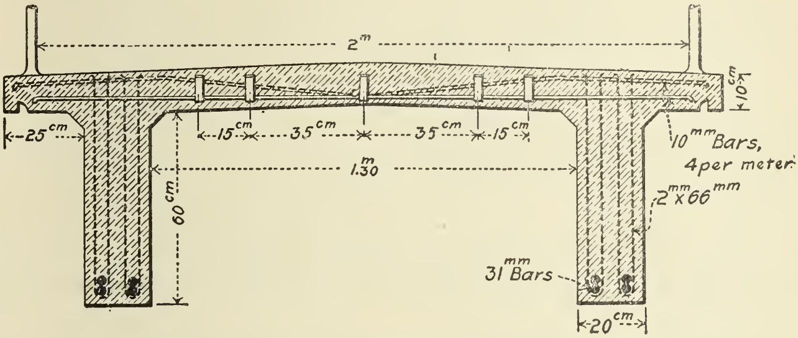
The Melan system is adapted principally for arch construction. Arched I beams or built up plate girders are constructed of a span sufficient to reach from abutment to abutment. These are spaced about two feet centres, and the space between and around them is filled with concrete.



Pier and Arch Construction of Melan Arches at Topeka, Kan. ("Re-inforced Concrete" p. 217.)

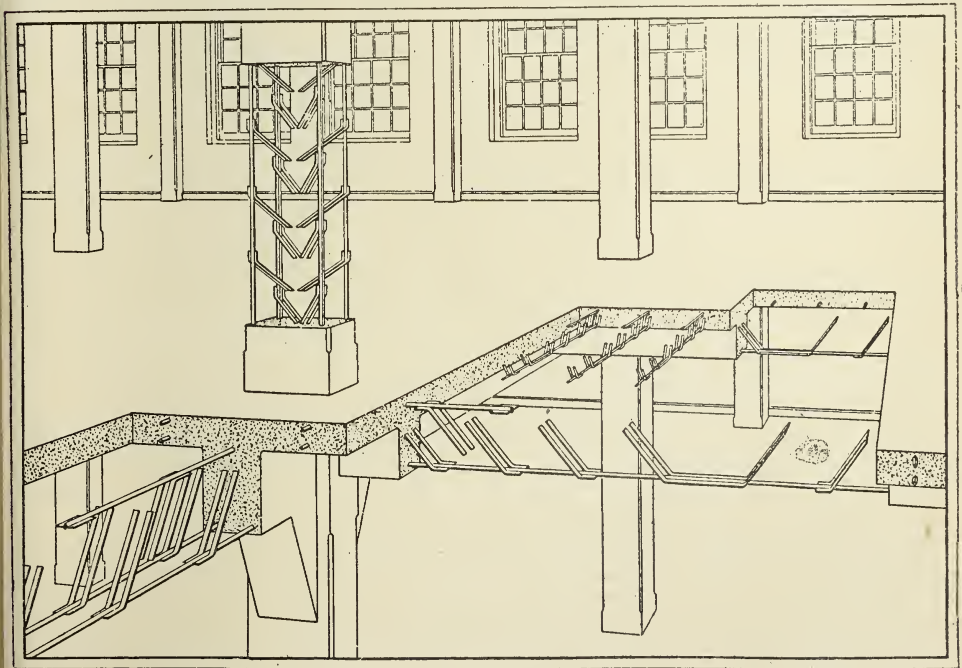
The feature of the Hennebique system is the use of the metal stirrup to resist the tendency to failure by oblique shear at the ends of the beams. These beams are reinforced by imbedded rods placed near the lower face, and at times by others near the upper face, to give rigidity and assist in resisting compressive stresses. The stirrups are of length slightly less than the height of the beams, and carry the

tension rods in their bends, the arch of the stirrup being downward. They are spaced more closely toward the ends, and are absent altogether at the middle section of the beam. Usually some of the tension rods are bent upward at the two ends, the object being to assist the U-shaped members in preventing end failure. The system lends itself admirably to the construction of columns. It has been very extensively used o the continent.



Hennebique System. Cross-section of Girder Bridge.
Note.—All dimensions are in the Metric System.

The Kahn system makes use of a "trussed bar" of steel with "fins" inclined outwards and upwards at 45° at both ends. Its merit seems to be that where tension

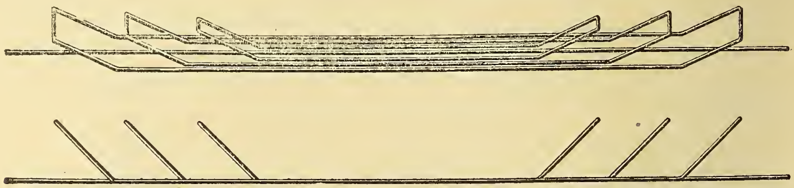


Perspective view of general adaptation of the Kahn System Trussed Concrete Steel Co.

alone is required, there is a maximum of metal available, and that to resist end-shear, oblique members more or less at right angles to the line of probable failure are provided. It is specially adapted for floors, columns and beams.

The Cummings system is analogous to that of Kahn. Here, however, round rods in nests of parallelograms are used, the ends of each being bent upwards, as are the

fins on the Kahn bar. The extra number of pieces required renders the placing of the metal somewhat more complicated than where a single bar is employed.



Cummings Bars.

The De Marr system makes use of flat steel bars having quarter turns alternately right and left every two inches or thereabouts, according to size. These bars connect from top to top of I beams, and in this way support the floor. It is frequently employed with a specially constructed tile or concrete floor block, which is used to build in between girder and girder.

In an article written for the Journal of the Royal Institute of British Architects, Mr. Frank Cawes gives the following rules for the construction of floors. No doubt it represents good English practice.

1. Obtain good cement.
2. Use good broken brick aggregate and not sand; body concrete to be of one part cement and four parts brick and the surface to be one part cement and three parts crushed granite.
3. Use as a precaution "sheep-wire netting" as a base, and steel bars of 1½ pounds per foot in weight spaced three feet apart.
4. Consider a slab 10 feet square by 4 inches thick capable of bearing 900 pounds per foot including its own weight, and reckon for every slab, more or less than 900 pounds per foot directly in proportion to the square of the thickness and inversely as the cube of the span. When the span is rectangular, the minimum span is taken.
5. Avoid casting slabs in frosty weather.
6. Cast large areas at once; have no partially cast slab over night.
7. Insist on strong centering. Leave it up at least five weeks.

SPECIFICATIONS FOR CONCRETE

The following specifications for Portland cement concrete are recommended by a committee of the American Railway Engineering and Maintenance of Way Association:

Cement: Cement shall be Portland, either American or foreign, which will meet the requirements of the standard specifications.

Sand: Sand shall be clean, sharp and coarse, but preferably of grains varying in size. It shall be free from clay, loam, sticks and other impurities.

Stone: Stone shall be sound, hard and durable, crushed to sizes not exceeding two inches in any direction, and freed from dust by screening.

Gravel: Gravel shall be composed of clean pebbles of hard and durable stone, of sizes not exceeding two inches in diameter, free from clay and other impurities except sand. When containing sand in any considerable quantity, the amount per unit of volume of gravel shall be determined accurately to admit of the proper proportion of sand being maintained in the concrete mixture.

Water: Water shall be clean and reasonably clear, free from sulphuric acid or strong alkalies.

Mixing by Hand: (1) Tight platforms shall be provided of sufficient size to accommodate men and materials for the progressive and rapid mixing of at least two batches of concrete at the same time. Batches shall not exceed one cubic yard each, and smaller batches are preferable, based upon a multiple of the number of sacks to the barrel.

(2) The sand shall be spread evenly upon the platform, then the cement upon the sand, and all mixed thoroughly until of a uniform color. The water necessary to make a thin mortar shall be added, and the whole spread again. The gravel, if used, shall then be added, and finally the broken stone, both of which, if dry, shall be first thoroughly wetted down. The mass shall then be turned with shovels or hoes until

thoroughly mixed and all gravel and stone are covered with mortar. This will probably require four turnings.

(3) Another approved method which may be permitted at the option of the engineer in charge is to spread the sand, then the cement, then the gravel or broken stone. Add water and mix thoroughly as above.

Mixing by Machine: A machine mixer shall be used whenever the volume of work will justify the expense of installing the plant. The necessary requirements for the machine will be that a precise and regular proportioning of materials can be controlled, and the product delivered shall be of the required consistency and thoroughly mixed.

Consistency: The concrete shall be of such consistency that when dumped in place it will not require much tamping. It shall be spaded down and tamped sufficiently to level off, and will then quake freely like jelly.

Course: (1) Each course shall be left somewhat rough to insure bonding with the next course above, and if it be readily set, shall be thoroughly cleaned and dampened before the next course is placed upon it. The plane of courses shall be as nearly as possible at right angles to the line of pressure.

(2) An uncompleted course shall be left with a vertical joint where the work is stopped.

(3) The work shall be carried up in sections of convenient length and completed without intermission.

Expansion Joints: (1) In exposed work expansion joints shall be provided at intervals of thirty to fifty feet. A temporary vertical form or partition of plank shall be set up and the section behind completed as though it were the end of the structure. The partition will be removed when the next section is begun and the new concrete placed against the old without mortar flushing. Locks shall be provided if directed or called for by the plans.

(2) In re-inforced or steel concrete the length of these sections may be materially increased at the option of the engineer.

Time: Concrete shall be placed immediately after mixing, and any having an initial set shall be rejected.

Facing: About one inch of mortar of the same proportions as used in the concrete may be placed next to the forms immediately in advance of the concrete, or a shovel facing made, at the option of the engineer in charge.

Forms: (1) Forms shall be substantial and unyielding, properly braced or tied together by means of wire or rods.

(2) The material used shall be dressed lumber secured to the studding or uprights in horizontal lines.

(3) Planking once used in forms shall be cleaned before being again used.

(4) The forms must not be removed within forty-eight hours after all the concrete in that section has been placed. In freezing weather they must remain until the concrete has had a sufficient time to become thoroughly set.

(5) In dry but not freezing weather, the forms shall be drenched with water before the concrete is placed against them.

(6) For backings, undressed lumber may be used for forms.

Finishing: (1) After the forms are removed any small cavities or openings in the concrete shall be neatly filled with mortar if necessary. Any ridges due to cracks or joints in the lumber shall be rubbed down. The entire face shall then be washed with a thin grout of the consistency of whitewash, mixed in the proportion of one part cement to two ports of sand. The wash shall be applied with a brush.

(2) The tops of bridge seats, pedestals, copings, wing walls, etc., when not finished with natural stone coping, shall be finished with a smooth surface composed of one part cement to two parts of sand. The wash shall be applied with a brush.
1 to 1½ inches thick. This must be put in place with the last course of concrete.

(3) In arch tops, a thin coat of mortar or grout shall be applied over the top to thoroughly seal the pores.

TESTS OF ONTARIO CEMENT

Following are the results of some experiments made with Ontario cements. It may be explained that samples of the various brands experimented with were either procured by the writer personally at the works, or were taken by him from original packages offered for sale by dealers in the open market, the packages bearing the maker's name and brand. Due care was exercised in every instance to get a fair sample of ordinary product. The experiments were made by the writer in the laboratory of the School of Practical Science, Toronto.

Sieve Test

Brand.	Residue on 50-mesh sieve.	Residue on 100-mesh seive.
	Per cent.	Per cent.
Portland:		
Monarch	0.1	5.7
Sun	0.0	1.9
National	0.1	1.7
Star	trace.	3.9
Samson	0.0	3.5
Imperial	trace.	5.4
Hercules	trace.	5.2
Saugeen	0.1	2.9
Giant	0.4	9.0
Natural Rock:		
Schwendiman's	2.3	12.9
Battle's	7.2	19.5
Ontario Lime Co's	6.1	15.7
Usher's	7.6	18.9

Hot Test

Pats were 6 hours in warm moist air, and 18 hours in water at 120° F.

Brand.	Remarks.
Portland:—	
Monarch	Satisfactory.
Sun	Satisfactory.
National	Satisfactory.
Star	Satisfactory.
Samson	Satisfactory.
Imperial	Pat separated from glass.
Hercules	Satisfactory.
Saugeen	Satisfactory.
Giant	Satisfactory.
Natural Rock:—	
Schwendiman's	Satisfactory.
Battle's	Satisfactory.
Ont. Lime Co.'s	Disintegrated in hot bath.
Usher's	Pat slightly curled up at edges.

Tensile Strength

Brand.	3 days.	7 days.	28 days.	Remarks.
	lb.	lb.	lb.	
Portland:				
Monarch	295	423	363	
Sun	343	483	798	
National	450	843	753	
Star	385	595	525	
Samson	320	458	608	
Imperial	465	720	903	
Hercules	338	648	910	
Saugeen	318	423	488	
Giant	400	593	618	
Natural Rock:				
Schwendiman's	51	54	115	
Battle's	80	95	138	
Usher's	80	100	103	

Tensile Strength—Mortar Test

Brand.	7 Days.	28 Days.	Remarks.
Portland, 3 to 1:			
Monarch	128	293	
Sun	168	308	
National	250	285	
Star	173	293	
Samson	128	210	
Imperial	163	260	
Hercules	208	270	
Saugeen	148	225	
Giant	150	250	
Natural rock, 1 to 1:			
Schwendiman's	48	130	
Battle's	73	133	
Usher's	28	125	

Samples of marl, limestone and clay, believed to be representative of the raw aterials used or proposed to be used by the various companies mentioned in this port, were collected by the writer when visiting the plants. These were sent for ialysis to Mr. A. G. Burrows, B.A., Sc., Provincial Assayer, Belleville, whose reports ereon are appended.

Analyses of Marls and Limestones

Name.	SiO_2. Per cent.	Fe_2O_3 Per cent.	Al_2O_3 Per cent.	$CaCO_3$ Per cent.	Mg CO_3 Per cent.	SO_3 Per cent.	Loss. Per cent.
PORTLAND:							
Hanover Portland Cement Co.	.58	.57	....	92.00	4.74	.52	1.66
Grey & Bruce Portland Cement Co.	2.00	.50	.84	84.91	2.89	1.21	6.60
Colonial Portland Cement Co.	.59	.64	....	87.39	2.96	.79	8.23
Lakefield Portland Cement Co.	.52	.16	....	93.43	.60	.51	4.07
Sun Portland Cement Co.	1.38	1.30	....	87.51	2.97	1.06	4.83
Imperial Portland Cement Co.	1.66	.63	.27	87.87	4.12	.72	5.69
Belleville Portland Cement Co.	4.12	.50	.93	92.29	1.42	.40	....
Ontario Portland Cement Co.	.30	.47	....	91.69	2.24	.41	2.22
International Portland Cement Co.	1.12	.38	.22	97.61	.51	.44	.20
Canadian Portland Cement Co.	.22	.18	....	94.61	.98	.64	3.19
National Portland Cement Co.	.74	....	.42	89.37	3.33	.60	5.65
Owen Sound Portland Cement Co	1.06	.82	.20	93.26	2.20	.51	2.41
Superior Portland Cement Co.	.26	....	.36	92.08	3.27	.55	3.67
NATURAL ROCK:							
Toronto Lime Co	7.04	1.51	2.34	48.27	40.36	.43	....
Isaac Usher	17.29	2.36	1.43	49.39	29.46	1.64	....
F. Schwendiman	10.08	1.77	3.31	46.18	37.77	1.40	....

Analyses of Clays

Name.	SiO_2 Per cent.	Fe_2O_3 Per cent.	Al_2O_3 Per cent.	Ca O Per cent.	Mg O Per cent.	SO_3 Per cent.	Loss. Per cent.
Hanover Portland Cement Co	46.47	6.97	18.91	7.05	3.97	.26	11.91
Grey and Bruce Portland Cement Co	37.50	4.79	12.45	19.30	2.96	.16	19.06
Colonial Portland Cement Co. (shale)	44.64	5.65	17.27	9.92	4.86	1.69	13.90
Lakefield Portland Cement Co.	39.58	4.02	11.26	19.86	2.74	.70	18.36
Sun Portland Cement Co	38.21	3.87	13.93	21.02	2.42	.24	20.36
Imperial Portland Cement Co	42.26	4.66	12.30	16.08	3.32	.12	18.16
Belleville Portland Cement Co.	51.98	8.94	20.00	1.62	3.33	.20	8.81
Ontario Portland Cement Co	51.72	5.66	14.11	10.59	3.03	.67	12.14
International Portland Cement Co.	55.92	8.72	18.98	3.64	4.48	.24	3.58
Canadian Portland Cement Co.	51.30	5.55	14.25	7.28	5.31	1.23	11.90
National Portland Cement Co	66.46	4.25	16.07	1.42	1.85	.23	5.32
Owen Sound Portland Cement Co	51.04	4.78	11.80	7.32	5.85	2.40	14.12
Superior Portland Cement Co	44.62	3.54	10.78	17.28	2.70	.23	....
Colonial Portland Cement Co	44.94	3.90	10.40	12.13	6.72	.56	12.47

EXPLORATIONS IN ABITIBI

BY JAMES G McMILLAN

In accordance with instructions received from Mr. T. W. Gibson, Director of the Bureau of Mines, an exploratory survey was made during the summer of 1904, of that portion of the northern clay belt lying west of lake Abitibi, and north of the area subdivided into townships by the Department of Crown Lands during the previous year.

Practically the whole of this area was, during the past summer, laid out in blocks consisting of four townships each, by meridian and base lines run at intervals of twelve miles, and a portion of the area, consisting of about a dozen townships, was still further sub-divided into lots.

The object of the expedition was to make a careful examination of the surface conditions prevailing in the region, including the geology as exhibited by the rock exposures, and the nature and capabilities—agricultural and otherwise—of the soil, in order that a body of information might be procured illustrative of the economic resources of the district and its suitability for settlement.

The information to be obtained was mainly of two kinds: (1) that connected with the geology and mineralogy of the region, and (2) that bearing upon its suitability for agriculture. The geological and topographical side of the work was in charge of the writer, while the latter was in charge of Mr. A. Henderson, B.A., late of the Ontario Agricultural College, who accompanied the party as agricultural expert, and who reports separately upon this branch of the work.

Besides Mr. Henderson and the writer, the party consisted of O. Mondoux, Copper Cliff; S. Comego, Sudbury, during the first two months in the field; and John L. Lang, Toronto, during the last month and a half.

On June 1st we took the early Canadian Pacific railway train, at Sudbury, for Matagama station, where our canoes were already awaiting us. Two days canoeing up the east branch of the Spanish river brought us to the Height of Land portage, after crossing which we entered the waters which flow to the Mattagami, and in two more days reached Fort Mattagami. After enjoying over Sunday the hospitality of Mr. Millar, the Hudson's Bay Company's factor, and of Mr. Hubert Southworth, chief fire ranger for the district, we again launched our canoes, and in a little over two days reached the first of the portages to Porcupine lake. At this point the work began, which was carried on for nearly four months. The return journey was made from the Frederick House river and Night Hawk lake, by way of Fort Matachewan, down the Montreal river to the Temiskaming and Northern Ontario railway, thence by rail to North Bay.

The plan followed in carrying on the work, was to make trips across country from points along the rivers to one or other of the survey lines, go about two miles along the line, and return to a point on the river where it had been agreed that the canoe should meet us. In this way the rivers were used as highways, and the country traversed at intervals of two or at the most three miles. Whenever the country to be travelled was too remote from the rivers to be reached in this way, a flying camp was moved in to one of the lines, and trips, usually one day in length, made from points on the line to a distance of five or six miles, returning to points two miles farther along the line, camp having in the meantime been moved the two miles along the line by one of the men. On the following day a similar trip would be made on the opposite side of the line, and ending two miles farther along.

Little attention will be paid in this report to the canoe routes used in going from point to point in the district, as they have been described by Dr. Parks, Dr. Kay and others in previous reports of the Bureau of Mines,[1] and also in reports of the Geological Survey.[2]

The report will be divided into four parts as follows :

I. The topography of the area.
II. The features of the separate parts in detail.
III. The resources of the area.
IV. The character of the rocks.

I. TOPOGRAPHY

The area is a plain, in all probability once the bed of a glacial-dammed lake. The only breaks in the general level are, the depressions caused by the erosion of streams, a few isolated hills of the "roche moutonneés" type, and some sand and gravel ridges of a morainic nature, which rise a few feet above the general level. Midway between the rivers of the region are some depressed tracts, once the beds of shallow lakes, but now filled with peat and moss to a depth of 4 to 12 feet. It is in these muskeg areas that most of the tributaries of the larger rivers have their origin. The remainder, comprising at least three-fourths of the whole area, is covered with a uniform deposit of clay and wooded with a mixed growth of spruce, poplar, balm of Gilead, birch and balsam, or almost entirely with spruce, according as the drainage is good or only medium.

Erosion has not gone on to a marked extent. This may be due in part to numerous barriers of rock which cross the rivers at intervals—in no case greater than ten miles—forming natural dams in the streams. Everywhere the valleys have a characteristic V-shape. At a short distance from the rivers, usually about 10 chains, the general level of the plain is reached; while the tributaries entering the main streams have valleys usually not greater than 10 chains in width. At no point is there a valley wider than half a mile.

The northern slopes of the few rocky hills are worn smooth and often striated by the action of the ice; while in the south in their lee, there is in most cases a deposit of sand or gravel extending a short distance from the hill. As the writer's aneroid went out of order, after a month's use, the height of these hills had to be estimated. Most of them appeared to be from 100 to 150 feet above the general level. Glacial striæ, where noted, have a direction between S. 5° W. and S. 10° E. The deposition of the drift materials, however, points to an advance of the ice from a direction about 10° west of north.

The Abitibi River

The Abitibi river flows out of Lower Abitibi lake, in a westerly direction, through the northern portions of the first three townships west of the lake, then forms a great U-shaped bend in the township of Teefy, before taking up its general direction—that of from 10° to 20° west of north. Above Couchiching falls, which are situated about five miles below the outlet of lake Abitibi, the banks are quite low; but below this point, the river has eroded its bed to a depth of 50 to 100 feet below the general level. The highest banks are in the northeast corner of the township of Teefy, where glacial accumulations, of morainic character, have added somewhat to the amount to be eroded; while below Iroquois falls, the banks are somewhat below the average height. Throughout this portion of its course, the river maintains a width of 4 to 5

[1] Eighth Rep. B. of M., pp. 175-180; Thriteenth Rep. B. of M., pp. 104-114; Report of Survey and Exploration of Northern Ontario, 1900, pp. 29.
[2] Geol. Sur. Can. Sum. Rep., 1901, p. 119.

chains As far as Couchiching falls the river is quite sluggish; then follow 2 miles of quiet river to the first rapid in lot 1, Knox township, where the fall is less than 2 feet.

From this point to the next rapid on the east side of lot 4 in Rickard, where the fall is 4 feet, and from here again to lot 6 in the same township, where there is a rapid with a fall of 3 feet, the river flows with an even current. These rapids may all be safely run on the left. For ascending there are portages on the same bank, while in addition there is an island portage of 8 chains at the second rapids mentioned. This is the better one to use when the current permits reaching the island. In the western half of Rickard are several rapids with a fall of 1 foot each, joined by stretches of swift water. These may be run with ease, and ascended without much difficulty. This is the only stretch of swift water in the upper portion of the Abitibi. Between this point and the Long Sault rapids, the sole obstructions to navigation are the rapids at the two portages and Iroquois falls, at each of which regular portages are provided on the left bank. The Buck Deer rapids, in concession VI of Aurora township, may be run with care, the only danger being from boulders in low water; and ascended by poling, or by making one or two lifts at the swiftest points.

Frederick House River

From the lower end of Frederick House lake the river of the same name flows, with an average width of about 3 chains, through the central part of the region, in a general direction parallel to that of the Abitibi below the great bend. The country to the north of Frederick House lake is at an elevation of only a few feet above that of the lake; and along the Frederick House river generally the banks have only about half the height of those along the Abitibi. They are highest below the falls in the first concession of Mann, below the three rapids in the fifth concession of the same township, and below Neelands rapids, at which points they have a height of about 50 feet. At most intermediate points the banks have a height of about 30 feet only. As on the Abititbi, the intermediate stretches are of quiet river, with a very moderate current.

The Mattagami

On the west of the area explored, the Mattagami river takes a westerly course for 6 miles from the great bend, just west of the township of Tisdale, in the district of Algoma, then bends again to the north and flows in a direction nearly parallel to that of the other rivers of the region. In the last mile of this western stretch of the river are three rapids, the portages past which are known as the Sandy portages. Above these portages, the banks are low and the current moderate; while below the current is, if anything, less swift between banks of a height of from 50 to 60 feet. The Mattagami is here a beautifully clear river, with an average width of 3 to 4 chains.

In addition to these—the principal—rivers of the region, a large tributary of the Frederick House river, which has not been noted by previous explorers, deserves mention. In its upper part, this river has two main branches; the western of which flows, from the large muskeg area in the townships of Wark and Gowan, as a creek with a width of 20 feet; and the eastern of which has its origin near the southeast corner of the township of Tully. After flowing in a northwest direction for about 12 miles, the first flows in a northerly direction for about 4 miles with a width of 50 to 60 feet, when it is joined by the eastern branch, which here has a width of some 30 feet. About five miles from the junction of these creeks the river is joined by another stream from the east, of about the same size as the smaller of the two. From the junction of the two branches, the river flows in a northerly course, and where next crossed about 7 miles farther north, it has a width of two chains and a depth of 8 feet. It crosses Patten's second base line at 4 m. 24 c., with the same width and joins the Frederick House probably 10 or 12 miles farther down. The

creeks, which drain the greater part of the township between Patten's meridian and the district line, have banks with a height of about 10 feet, and the river below the junction has banks about 20 feet high.

Lakes and Ridges

With the exception of Frederick House lake which is in the area reported upon last year, and lake Abitibi, which forms the eastern boundary of the area, none of the lakes are of sufficient size to form marked physical features. For the most part they are less than a mile in length and fill kettle holes or other depressions in glacial accumulations. Starting near the west bay of Frederick House lake in the township of Evelyn, the most important ridge of glacial material extends for about 30 miles in a direction roughly parallel to and at a distance of 2 to 4 miles from the river. In the southern part the ridge is of sand, wooded with jack-pine and of considerable width. It narrows in the township of Little, and from Beaver lakes near the northwest corner of the township for about 5 miles it is composed largely of boulder clay. A break of 3 or 4 miles occurs about Patten's correction line, after which the ridge can be traced to his second base line. In this part it has a width of about half a mile, with a chain of small narrow lakes and peat bogs occupying a depression within the ridge. The greater part consists of sand; the depressions left by masses of ice which became covered and melted after the body of the ice had retreated, show in places a depth of 60 feet of that material.

At about the same distance east of the Frederick House river a similar ridge, consisting mostly of boulder clay, extends from Speight's base line for about 10 miles in a southerly direction. In the north central part of the first township east of the district line and south of the base line there are several lakes; none however exceed a half mile in length. In the township south of the one just mentioned are several lakes the last one being over one mile long, but very narrow.

In the northwestern part of Calvert township, and extending some distance into McCart is a sand area, at least 2 miles wide, with a number of lakes whose longest axes are in a direction east of north and west of south. Corresponding to this direction the only glacial striæ noted had a direction S. 5° W.

The second largest ridge of glacial material crosses the Abitibi river in the northeast corner of the township of Teefy. It extends in a direction parallel to the two ridges mentioned, as far south as the south townline of Rickard, but only for a distance of about 2 miles north of the river. On the latter side of the river there are two lakes, the largest of which is about 60 chains in length, of beautifully clear water. A portage leads from the river along the gravel ridge to these lakes, which judging by its appearance is much used by the Indians during the hunting season. South of the river are several small lakes, from the more northerly of which a creek has cut through sand to a depth of 60 to 80 feet, and reached the underlying clay.

The largest muskeg area crosses the northern halves of the townships of Wark and Gowan. The only others which exceed two miles in greatest length lie in the west central part of Newmarket, the east central part of Edwards, and the south central part of Moody township.

II. THE REGION IN DETAIL

Speight's Meridian to Mattagami River

The meridian line was reached by ascending a creek about 30 feet in width, which enters the Mattagami river from the north, at the westerly bend of the river. This creek flows out of the township of Murphy, crossing the line at 7 m 60 c., with a width of 15 feet. After ascending the creek for some 3 miles, the line was reached

at 6 m. 60 c., by travelling in an easterly direction across flat clay land wooded mostly with spruce. To the west of the creek near its mouth is a small sand area covered with jack-pine, averaging about 12 inches in diameter.

Along the west boundary of Murphy the country is very level. Though apparently flat and somewhat wet at this season—June 10th—the land is at least 100 feet above the Mattagami river, as indicated by several aneroid readings taken when going out from, and returning to, the river. Miles 8 and 9 cross flat clay land, wooded with spruce averaging about six inches. In mile 10 the clay soil is covered with about 2 feet of moss and mould, and the spruce is rather smaller in size. From 10 m. 40 c. to 11 m. 30 c. the line crosses a muskeg with a depth of peat of at least 7 feet. At 11 m. 55 c. a creek 6 feet wide flows to the west, and this half mile is well drained. For at least 10 c. on either side of the creek, the timber consists of fairly large spruce and poplar, and the clay soil is not moss-covered.

From the 12-m. post on Speight's meridian, a trip was made in a westerly direction to the Mattagami river, which was reached at 8 m. 50 c. The first two miles of the trip cross an area of good clay land, wooded with spruce averaging about 6 inches on the low ground, and with larger spruce, poplar and balsam on the knolls. At 1 m. 72 c. the creek just mentioned was crossed. It here has a width of 8 feet and flows to the northwest. For some distance on either side of our course from 2 m. 20 c. to 2. m. 55 c. the country had been recently burned. This was the only lately burned area seen during the summer, and was of small extent. At the latter distance a creek 15 feet wide was encountered also flowing northwest, to the west of which a rather wet clay area extended for 65 c., followed by 56 c. of muskeg, which apparently extends a considerable distance to the southwest. From 4 m. 16 c. to 5 m. 20 c. the clay soil is covered with about 3 feet of moss and mould and timbered with spruce not exceeding 5 inches in diameter, except for a few chains on either side of a creek 12 feet wide flowing northwest, which was crossed at 4 m. 64 c. At 5 m. 20 c. a muskeg 16 c. wide was encountered, then 64 c. of wet clay land much grown up with black alder, followed by 35 c. of muskeg extending to 6 m. 55 c. These narrow strips of muskeg appeared to be arms of a larger muskeg to the south of our course. At 7 m. a creek 12 feet wide and 2 feet deep flows north through clay land thinly wooded with spruce. At 7 m. 30 c. the larger spruce and drier clay land bordering the river was encountered, and at 8 m. 40 c. the descent to the river began. The bank here is 60 feet high (aneroid) and is wooded with spruce and poplar averaging about 15 inches for some distance back, while close to the river are also balm of Gilead or balsam poplar of 20 inches and cedar of about 16 inches diameter.

The Mattagami Valley

The east bank of the Mattagami was then followed up stream for about 4 miles, in a direction a little east of south. The banks are of clay, with a rise of 50 or 60 feet from the river in a distance of about 10 chains. Rills cut down through the clay at comparatively regular intervals of about 10 chains, but no streams of any note enter the river from the east, and only one, the Kamiskotaia, a river about 1 chain wide, enters from the southwest. The timber along the bank consists of balm and cedar, up to 2 feet diameter, together with spruce and poplar of somewhat smaller size.

The return to camp was made from this point by canoe. About 5 miles up stream, the Water Hen creek enters from the south, and a short distance above the lower of the three portages is reached. This is a sandy portage, 10 chains in length, on the north bank. The middle and upper portages, which are about 32 c. and 80 c. up stream from the lower, are each 20 c. long, and on the south bank. Considerable current is encountered in reaching and in leaving the upper portage. About 10 miles farther up stream the portage to Porcupine lake leaves the Mattagami.

The outcrop of rock at the three portages has been previously described by Dr. Parks. On the north bank of the river at the upper rapids the rock is a porphyry—gray in color. The only additional outcrop seen is on the east bank about 5 miles below the lower rapids. At this point a weathered greenstone shows at the water's edge.

A trip was also made in a westerly direction to the Mattagami river from the 9-m. post on Speight's meridian. For the first mile and a half the soil is a good clay covered with about one foot of mould, and wooded with 6-inch spruce together with a few poplar and balm on the higher ground. The next mile and a half is typical of large areas in this region. The principal tree has been the tamarack, which was killed some years ago by the larch saw-fly. The killing of the tamarack has left the woods rather open to the sunlight, and a thick growth of alder has sprung up among the more or less scattered spruce. Many of the dry tamarack are still sound and would make good wood or ties; but they are decaying at the roots and are being gradually blown down, making with the alder a tangle through which it is hard to pass.

The soil is always clay overlain by 1 to 5 feet of mould. The spruce in these areas is usually somewhat larger than in the regular spruce woods, and the depth of moss considerably less. The only creek is one 3 feet wide flowing south at the end of the first mile. At 3 m. a muskeg 32 c. across was entered. The rest of this mile is wooded with spruce of about 5 inches, and is covered with a depth of 2 feet or more of moss. The next two miles is entirely muskeg with varying depths of peat. At 5 m. a sounding was made by driving down a pointed pole and a sample taken at a depth of one foot. The depth of peat at this point was 6 feet, and at 6 m. the depth was at least 7 feet. In the first half of the 7th mile, the soil is clay deeply covered with moss and wooded with small spruce. This is followed by 24 c. of spruce and poplar, and this in turn by 24 c. of small spruce. From this point to the river which was reached at 7 m. 70 c., the timber is of good size, and the land dry. The white spruce would average 10 inches, the poplar 15, and the cedar and balm probably more.

The river bank at this point has a height of 54 feet (aneroid), and in the gradual slope of the first mile back from the river there is an additional fall of 50 feet (aneroid); so that, the total fall from the level area in the interior to the level of the river is about 100 feet.

The trip was continued from the point on the river just reached, by following the east bank upstream for half a mile, and then taking a course S. 30° E., to the foot of the upper of the three rapids, previously mentioned. The pebbles noted in the beds of the rills here entering the river consist of granite, groonstone, and silicious schist. For the first mile the soil is a good clay, well wooded with the varied timber found along the rivers in the region. At 8 c. on the second mile is a lake 8 c. long, from which a small creek flows to the south. The rest of this mile is level clay land wooded with spruce. At 24 c. on the third mile, a creek 6 feet wide with a bank 30 feet high crosses our course, then turns and follows it for half a mile, when it again turns to the southwest. Tributaries enter this creek from the east at 34 c. and 64 c. The soil is of the same uniform nature, timbered with spruce and balsam. The first 48 c. of the fourth mile is wet clay land, timbered with spruce, averaging 8 or 10 inches, and dry tamarack. Then the land rises about 20 feet, while stony and gravelly soil succeed for a distance of a little over one mile, and balsam and birch replace the tamarack. This is followed by 16 c. of tamarack swamp, when the large timber and dry clay soil of the river margin is entered. At 5m. 24 c. a creek 4 feet wide flows to the west, and at the half mile the foot of the rapids is reached.

The Mattagami river has here a width of about 3 c. and flows almost directly west. To the head of the upper rapids is about 60 c. and the fall in this distance is 12

feet (aneroid). Above the rapids the country has the same general character, but is at a less elevation above the river. After one hour's good paddling in an easterly direction, the river again bends to the south, at the point where the creek ascended at the beginning of the trip enters from the north, and in a little less time the first portage to Porcupine lake is reached.

Wark Township

Two trips were made through this township, one on the west and the other on the east side, from Speight's base line, which forms the southern boundary.

Travelling north from the 12-m. post on Speight's meridian, the first 60 c. is muskeg, and the rest of the mile clay land, timbered with spruce and poplar. The next 20 c. is quite mossy and covered with scrubby spruce, then follows one mile of good clay land wooded with spruce, dry tamarack and alder, with some poplar on the knolls. At 2 m. 20 c. the land becomes a little higher, and spruce and poplar woods follow to the end of the mile.

The fourth mile passes through a typical spruce woods, with timber averaging 6 inches. The soil is a good clay under one foot of moss and a varying depth of mould. At 42 c. and at 70 c. creeks of widths of 6 and 4 feet respectively, flow to the west. In the fifth mile, the first 35 c. have a depth of 5 feet of peaty mould and scrubby spruce timber. This is followed in turn by 5 c. of poplar knoll, 10 c. of muskeg open to east and west, 10 c. of spruce knoll and 50 c. of muskeg, with a depth of 6 feet of peat. The remaining 50 c. of the sixth mile is level clay land, timbered with 5-inch spruce and poplar. At 5 m. 55 c. a creek 5 feet wide flows to the east.

Travelling eastward from this, the northwest corner of the township—the first 60 c. is good clay land covered with about 2 feet of moss and mould, and a good growth of 9-inch spruce. At 75 c. a creek 15 feet wide and 4 feet deep flows to the north, and at 1 m. 65 c. another of 16 feet width and 2 feet depth flows to the northwest. The land between these two creeks is equally good, but the timber is much smaller, averaging about 5 inches.

Turning in a southerly direction at a point 2 miles east of the corner mentioned, the same creek is soon crossed a second time. At 15 c. a muskeg 25 c. wide is entered, and at 54 c. a creek 40 feet wide is noted lying just to the east of our course. This is probably the same creek dammed by beaver, as on a creek 6 feet wide flowing east at 67 c. beaver cuttings are quite plentiful. Along these creeks the timber consists of 6-inch spruce and 14-inch poplar, growing on a good clay soil. Then follows half a mile of the same spruce, on a good clay soil covered with about one foot of moss. At the half mile, 10 c. of poplar knoll is encountered, the rest of the mile being of the same character as the first part. In the first half of the third mile, the spruce is small and the depth of moss about 3 feet. From 2 m. 40 c. to 4 m. is a large muskeg, open for at least 1 mile to the west and having a depth of at least 9 feet of peat. At 3 m. 50 c. a blazed trail bears S. 50° E., probably to the Porcupine river, as a similar trail was noticed leaving one of its branches. In the first half of the fifth mile the spruce is small and the land wet; then follow in turn 20 c. of muskeg and 50 c. of spruce and poplar woods and dry clay land. A creek, 10 feet wide, flowing east at 5 m. drains this area. From 5 m. 30 c. to 5 m. 60 c. the soil is a good clay with a growth of 10-inch spruce. From this to the line, which was reached at 2 m. 40 c., the spruce is very scrubby and the moss deep.

The east half of the township was explored by travelling along the south boundary to the 6-m. post on Speight's line, and making a trip similar to the last 6 miles north from this point.

A hard green schist, containing some quartz stringers, outcrops along the line at 2 m. 55 c. and at 3 m. 8 c. Near the 4-m. post is another outcrop of similar rock,

with some layers quite soft and dark in color. At 4-m. 12 c. low rocky ridge extending some 14 c. to the north, has much the same nature, but in places has the appearance of a tuff or ash rock.

The land between these two outcrops is composed of good clay soil, drained by a creek seven feet wide, flowing north at 3 m. 28 c. From the last outcrop to the 6-m. post, the soil is mostly clay. At 50 c. on the fifth mile, the line crosses a sand knoll 15 c. across; and at 12 c. on the sixth crosses a creek 16 feet wide flowing southeast.

Going north from the southeast corner of the township, the first mile is dry clay land with here and there granite and greenstone boulders. In the second mile the first half is lower and wooded with small spruce only, and the last half muskeg. In the third mile, the first 35 c .are wet and the spruce small. This is succeeded by one mile of clay land, wooded with 6-inch spruce, and covered by 1 foot of moss. Then follows 80 c. of muskeg, which extends to a considerable distance east and west. A sounding taken at 4 m. gave a depth of peat of at least 7 feet. The spruce woods extending to the north of this area, contain trees averaging 6 inches. The last 30 c. of the sixth mile pass through another muskeg, with a depth of peat of 9 feet, and extending 20 c. to the west. To the west of this the same spruce woods extend for 60 c., then follow 40 c. of muskeg, apparently an arm of a larger one to the northwest. This is followed by a half mile of wet spruce woods, in which the clay soil is covered with about 4 feet of moss and mould.

Turning to the south after travelling two miles westward, the first 100 c. is good clay land covered with 1 foot of moss and mould, and wooded with 5-inch spruce. At 27 c. and at 54 c. creeks 3 feet wide flow to the west. Along these creeks the spruce is much larger and is mixed with 12-inch poplar. The next 100 c. up to 2 m. 40 c. is muskeg, with a depth of peat of 7½ feet. South of this muskeg the land slopes very slightly to the south. The soil is a good clay covered, except along the creeks and on the knolls, with about 1 foot of mould. At 4 m. there is about a quarter of a mile of wet land with 6 feet of moss and mould, and timbered with small spruce; but over the rest of the area the spruce would average six or seven inches in diameter. The poplar growing along the creeks and upon scattered knolls would average 12 inches. At 5 m. a creek 16 feet wide and 2 feet deep, which drains the south half of the township, flows to the southeast, while a branch 4 feet wide enters it from the north. At 3 m. 50 c. another creek 3 feet in width flows to the east. After passing through half a mile of spruce and poplar woods the line was reached at a point 8 c. east of the 4-m. post.

A Muskeg Area

The northern half of the township of Gowan is very similar to the same portion of Wark. A muskeg with a depth of peat varying from 4 to over 9 feet stretches from west to east across the two townships. This was crossed from north to south at intervals of 2 miles. Two miles from the east boundary of Gowan the width was two miles and a half, and the depth from 5 to 6 feet. At the same distance from the west boundary of Wark, the width was one mile and a half, and the depth over 9 feet. At the other four points the width was a mile and a quarter.

Where the depth of peat exceeds 4 feet, these areas are practically open. Though scattered spruce and tamarack of an age as great as that of any trees in the region are found upon them, they rarely exceed 15 feet in height, or 3 inches in diameter. Many spruce were seen with 150 annual rings and a diameter of 2 inches. Together with these scrubby trees there is, in many places, a dwarf birch which is a mere shrub from 2 to 4 feet in height. In June the previous year's berries were still fresh upon the cranberry bushes.

This muskeg is the source of some important streams. Mention has already been made of the creek flowing out of it to the north, which, after some miles, forms a considerable river. Two at least and possibly three creeks of a width of 15 feet flow out of the northwest corner, and must before they reach the Mattagami river form a stream of considerable size. From the south side the drainage is to the Porcupine river. Besides the creek previously mentioned as flowing to the southeast through Wark, a creek 10 feet in width also flows into the north branch of the Porcupine from the west side of Gowan, while from the east side a creek 16 feet in width flows south into the Porcupine below the junction of the north branch with the main stream. Upon the upper part of the last mentioned creek a beaver dam 5 feet in height was seen and in fact on nearly every stream beaver cuttings and work are plentiful. These last two creeks drain an area in every respect similar to that in the south of Wark township.

Spruce Forest

To the north of the area just described, and in the townships of Prosser and Tully, is an extensive area of spruce woods. The timber averages from 6 to 10 inches in diameter, the larger size being found along the creeks where there are a few poplar mixed with the spruce. The trees are young and thrifty, and the woods remarkably clean and free from windfall. In the parts remote from the creeks, the best timber is found in the third concession of Prosser, where the spruce averages from 8 to 10 inches in diameter. In this part the soil is covered with a depth of 2 to 4 feet of moss and mould; but over the greater part of the area there is only sufficient moss to form a carpet for the ground.

The creeks which flow in a northwesterly direction from the centre of the southern part of Tully are very little below the level of the area. The average width of the larger stream is about 20 feet in the second concession of Tully, where it flows through lot 8. This increases to about 30 feet where it leaves the township of Prosser on the east side of lot 5. The more easterly stream has, in lot 5 concession IV, Tully, a width of about 12 feet; while between lots 8 and 9, where it leaves the township the width has increased to nearly 30 feet. Beaver dams in many places give this stream a width of over 20 feet, and the larger a width of 50 to 60 feet.

Though the banks are only a few feet high the land is, for the most part, fairly dry and the soil a uniformly good clay. A ridge of sand and gravel about half a mile wide runs east and west through the fourth concession of Prosser, for at least four miles in the middle of the township. The timber on this ridge consists of spruce and birch, averaging 12 inches in diameter, and poplar averaging 18.

Muskegs are not extensive within the area. Lots 4 and 5 in the sixth concession of Tully have a depth of peat of about 6 feet, and in the other lots in the northeast corner of the township there is also considerable muskeg. About half of lot 8 in the fourth and fifth concessions have a depth of 4 feet of peat.

The only muskeg seen in the township of Prosser was one in lots 4 and 5 in the fifth concession, which had a width of about 35 chains.

Rock Outcroppings.

Several outcrops of rock were noted within this area. In lot 5 in the third concession of Tully several ridges, from 10 to 30 feet high, run east and west. The rock is a much weathered greenstone, fine-grained in structure, and showing the presence of decomposition products. In the southern part of lot 8 in the second concession of Prosser, there is a hill, about 120 feet high, the central portion of which consists of breccia, while the sides are flanked by an iron-stained schist, grey in color, with a strike of N. 70° E., and a dip about 75° to the north. A green schist outcrops in the northern part of the same lot in the third concession; and

within about 10 chains of the northwest corner of the township another outcrop of schist rather lighter in color occurs. These have the appearance of altered greenstones.

The boulders noted within the ridge previously mentioned comprise greenstone, granite and schists of much the same character as those within the area. In the bed of the larger creek where it flows out of the township, a pebble of greenstone containing considerable pyrrhotite was noted.

Patten's First Base to His Correction Line.

This is an area of uniform clay land, but of quite varied timber growth. The latter feature is largely due to a considerable part of the area having been burned over—the larger portion some 40 years ago, and a smaller portion about 10 years ago. The opening produced by these fires has led to the extensive windfalls in the adjoining timbered parts.

The largest area of windfall surrounds the 12-m. post on Patten's meridian. This extends for nearly 3 miles into the township of Prosser, and for over a mile north from the boundary. A trip west from this post showed that tamarack windfall extended for about 3 miles in that direction, but a mile north of this fairly good spruce of 6 to 9 inches in diameter grows quite free from tamarack. This area is mostly of wet clay land, and in this part the dead tamarack only are blown down, leaving thin spruce woods; but on the higher land many balsam and some spruce in addition to the tamarack have been uprooted.

Another windfall area extends for about 2 miles along the creek which flows to the northwest from the township of Tully. This area reaches east to a muskeg in lot 5 of the sixth concession of Tully, but not over half a mile to the west. The creek through this part has a bank from 8 to 10 feet in height, but the land is at almost a dead level. As a result the natural drainage is not good.

At the point where the larger of the two creeks crosses Patten's base line, the land has an elevation of some 30 feet above the level of the creek. This dry clay area extends along the creek with a width of over a mile, for at least 1 mile straight north and for nearly the same distance south into Prosser. The timber is of no value, as it consists of scattered brushy spruce of about 40 years' growth; but the soil is a good clay, fairly well covered with grass where the trees are very scattered.

Along the same creek to the northwest of this area, a brulé of 10 years extends for about 2 miles. Where crossed in going east from the 14-m. post on the meridian line, it has a width of over a mile. Part of the same brulé crosses the meridian just north of the 14-m. post with a width of 32 chains. This area is commencing to grow up with young spruce, poplar and tamarack.

The portion of the area lying along the Correction line for the whole 12 miles, along the creeks through the northern part of the area, and between these to within a short distance of the base line, is mostly spruce woods. For a quarter of a mile along the creeks the spruce is large, some reaching a diameter of over 2 feet; but over the greater part of the area the average diameter is from 8 to 10 inches. The soil throughout is clay covered with a depth of moss and mould varying from 1 to 3 feet.

A trip west from the 16-m. post on the meridian line for a distance of 3 miles crosses a similar area. From near this post a creek 12 feet wide flows east to join the west branch which is here about a mile distant. About 2 miles west a creek of the same width, but increasing to 20 feet in width a mile to the west, flows in a northwesterly direction to the Mattagami.

Along this latter creek the spruce averages 1 foot in diameter, and the soil is fairly dry; but over the rest of the area west of miles 17 and 18 the spruce averages from 6 to 8 inches, and the soil is covered with 3 to 4 feet of moss and mould.

The muskegs, though larger than in the spruce woods to the south, do not comprise much more than one-twentieth of the whole area. At 13 m. 40 c. on the meridian line a muskeg crosses in an east and west direction, with a width of some 30 chains. North of lots 1 and 2 in the sixth concession of Prosser there is a muskeg probably about 300 acres in extent, while in the third and fourth miles north of lot 4 in the same concession there is another of about a square mile in area, from which three creeks with widths of 4 to 10 feet flow east to join the east branch. About 3 miles east from the 16-m. post on the meridian is another area a mile in width. Three miles north of the 8-m. post on the base line a muskeg with a width of 50 chains was crossed, while in the northeast corner of the area is the only other of any considerable area in the part east of the smaller branch. The depth of peat in each of these muskegs is about 6 feet.

In the eastern part of the section, the area of glacial accumulations which extends from Beaver lakes to a point on the Correction line midway between the two lakes in the third mile, forms a divide between the basins of the Frederick House and of the streams of the section. The soil is a good clay mixed with a considerable proportion of sand; and the land has a sufficient relief to be quite dry. The timber growth is about 40 years old and consists of poplar and balm of 8-inch size, and a thick growth of small spruce, except between the two lakes mentioned where the timber is of greater age, the poplar having here a diameter of 16 inches.

The only rock seen within the section outcrops just east of the brulé at a point about 3 miles northeast of the western end of the base line. This is an altered greenstone with a peculiar granular structure, probably due to the weathering of the original constituents.

The Basin of the Mattagami

For the next 12 miles north to Patten's second base line, this stream flows through an area of clay land superior in respect to drainage to those previously described. The difference in level of 15 to 20 feet between the bed of the stream and the plain is sufficient to drain the country in its present condition for some 2 miles on either side of the river. In the northern half of the basin, where the slope is somewhat more marked, the clearing of the land would no doubt provide good drainage for an area twice as large.

In the southern half of this portion of the basin, the timber is of little value for about 2 miles on the west side of the river. This part was burned over some 40 years ago, and is now covered with a thicket of young spruce and tamarack, except in the swales, where some of the original spruce timber remains.

The 21st, 22nd, and part of the 23rd miles on the meridian line pass through spruce woods with timber averaging 6 or 7 inches in diameter. About the 23-m. post there is a muskeg probably a mile in length with a depth of peat of 4 or 5 feet, while two miles east of the 22nd mile there is another of about the same size with 5½ feet of peat.

Along the east branch, which forms a junction with the main stream about 2 miles north of the 9-m. post on the Correction line, the spruce is of an average size of 12 inches. In the area between the two branches however the spruce is smaller, averaging probably 8 inches in diameter.

The only glacial accumulations seen in the southern portion of the area were crossed 5 miles north of the fourth mile of the Correction line. Two lakes were seen here, one quite small, filling a kettle-hole, and one half a mile in length, apparently with an outlet to the northeast. At five miles north of the 4-m. post, a muskeg apparently occupies a depression within the accumulations, since for half

a mile to the south there is the same slightly stony clay soil, with a marked southern slope. Upon this soil the spruce and poplar grow very large, some reaching a diameter of 2 feet.

Between these glacial deposits and the Correction line is an area of spruce woods, with muskeg half a mile in width in the northern halves of the second and third miles from that line. A creek, which crosses the Correction line at the 4-m. post with a width of 12 feet, and which flows north and turns to the northeast with a width of 20 feet at a distance of one mile from the line, one 20 feet wide flowing west 2 miles from the line, and a third 15 feet wide flowing out of a small lake at a distance of 3 miles 24 chains from the line, drain this area, and in all probability together form a large stream entering the river at some point midway between the Correction and Base lines. This area is quite level, and is timbered with spruce averaging from 6 to 8 inches in diameter.

In the northern half of the basin, in addition to the ridge of glacial material which forms the divide on its eastern side, there is a second ridge crossing the base line at the 6-m. post. West of this ridge is a small lake, followed by half a mile of sand timbered with thrifty young poplar and birch one foot in diameter.

Along the Base line from this sand area to the river and for 2 miles to the west the timber is of little value, consisting for the most part of young brushy spruce, together with some poplar and birch on the higher ground. The rest of the northern half of the basin, excepting the muskeg portions, is covered with good spruce, poplar, balsam and birch of about 70 years' growth. The first largely predominates in the parts at a distance from the river, while poplar is the chief timber close to the streams. The latter two occur to a lesser extent on the higher ground.

Narrow strips of muskeg occur quite frequently, but few of them exceed 16 chains in width. The largest crosses the Base line in the middle of the first mile and meridian at 24 chains on the thirtieth mile, with a width of about 48 chains, and a depth of peat of 7 feet. The middle of the 28th mile on the meridian is occupied by a muskeg about half a mile across. Three miles south of the middle of the 7th mile on the Base line there is a marshy lake about 60 chains long, lying in a north and south direction, and about 20 chains in width. A creek 16 feet wide flows from the northwest corner. On the east side of this lake there is a mile and a half of good spruce, averaging 8 inches in diameter, while to the west there is 30 chains of muskeg.

The only outcrop of rock noted occurs in the third mile north of the 8-m. post on the Correction line. The rock appears to be a syenite. It is very much weathered and the dark minerals of the rock are greatly altered.

The Frederick House Basin

This basin was explored from Frederick House lake to the base line run east and west from the 162-m. post on the district line, a distance of 24 miles north and south. It has been pointed out that the western portion of the basin is small, varying from 2 to 4 miles in width. The eastern portion has nearly a uniform width of about 6 miles. Three important tributaries enter the river in the northern half of this portion of the basin, one from the east and one from the west near the 156-m. post on the district line, and the third from the east at a point about 3 miles farther up stream. The only large stream, entering the river in the southern half, drains the township of McCart, and joins the river with a width of about a chain to the north of an island in the river about 2 miles below the outlet of the lake.

The largest creek in the western part of the basin has its source in a lake about half a mile long which lies immediately west of the 2-m. post on the Correction line, and in a wet clay area to the east of this lake. It flows north for about 2 miles,

then bends to the northeast with a width of 15 feet, and crosses the district line in the 155th mile with a width of some 30 feet. The area drained by this stream has a good clay soil covered with from 1 to 2 feet of mould, and with a timber growth consisting mostly of spruce. Along the Correction line, the timber averages 10 inches, and along the middle portion of the creek from 6 to 8 inches in diameter, with considerable tamarack windfall throughout.

From this stream north to the base line, the soil is of the same character, but higher and well drained. The timber growth is of mixed kinds and of a good size. A section of this area at a point about 2½ miles from the base line showed over a mile of this timber along the river on the west side.

On the opposite side of the Frederick House, a trip made from Neelands rapids to the 162-m. post, showed the presence of about the same width of mixed timber, followed by spruce woods to within a half mile of the corner, where the wet clay land changes to muskeg. On the east side of the district line there is almost another mile of 10-inch spruce. A trip inland from near the point where this line crosses the river was made through a narrow margin of mixed timber and a mile and a half of 8-inch spruce to a muskeg 30 chains wide opening out to the north.

The largest of the three tributaries probably has its source in a muskeg situated one mile west of the middle of the east boundary of the first township south of Speight's base line, and east of the district line. It flows about 2 miles west, when after being joined by branches which drain the northern part of the township it turns sharply to the south for three miles, leaving the township near the middle of the south boundary with a width of one chain. A short distance above this point it is joined by a creek 15 feet wide flowing out of a series of lakes which lie about 4 miles east of the district line in the southerly one of the two townships. For the lower 4 or 5 miles of its course, the creek makes a big bend to the south into this township, joining the Frederick House near the point where the north town line will cross that river.

The eastern two-thirds of the more northerly townships is another of those areas which have been burned over. The timber is of little value, consisting for the most part of a thicket of spruce and tamarack of about 40 years' growth. About the middle of the east side of this township there is a considerable area of high land wooded with thrifty mixed timber of remarkable growth. Some of the poplar with 40 annual rings have here a diameter of 14 inches. Over almost the whole of the area the soil is a good clay, and for the most part the land is dry.

The land along the lower 5 miles of the last-mentioned creek has also a good clay soil, but it is much lower. The timber is mostly spruce, which along the creek will average 12 inches in diameter, but at a distance therefrom is considerably smaller. To the east of the bend in the creek, an extensive windfall has practically destroyed the timber. To the west of the middle one of the three lakes mapped, there is a mile of large poplar and birch timber on high clay land, which is probably a remnant of one of the glacial ridges of morainic origin.

In all other respects, except in size and in direction of flow, the third of these tributaries is a duplicate of the last. It has its source in a large muskeg about 2 miles west of the centre of the township of Newmarket, and flows in a northwesterly direction, crossing the north-east corner of lot 3 in the fourth concession of Mann, and Galbraith's base line at a point 10 chains west of the 4-m. post. It is about one-third the size of the more northerly stream. Below the Base line the timber consists of spruce of 9 to 12 inch size, balsam and balm. Above this line, for a width of 3 miles along the creek, the timber is second-growth of the same character and age as in the areas previously described. The largest of these spruce trees have a diameter of 6 inches.

Between the 144th and the 150th miles on the district line, the Frederick House river flows within about 2 miles of the western side of its basin. The soil in the western part of the basin at this point is a somewhat gritty clay and quite dry. The timber is second growth of no value, some of the poplar only reaching a size of 8 inches. This area of second-growth timber is connected with the one in the north-east part of Mann by a strip of the same about 60 chains wide in the fourth concession of that township. Beaver lakes have been described by Dr. Parks in the 1899 Report. The only lakes seen in this part in addition to these were two V-shaped lakes 20 chains in length situated at distances of one and two miles respectively to the north of Beaver lakes.

For a distance of about one mile from the river on the east side the timber is of a mixed character, being young and not very large. The poplar and balm average about 1 foot, and the spruce 8 inches in diameter. At a greater distance from the river the timber consists mostly of 8-inch spruce. The only land not suited for agricultural purposes is a muskeg area about a mile across one mile west of the southeast corner of Mann, and a small rocky area in the second mile north of this point.

The southern portion of the basin has a width to the west of the river of between 2 and 3 miles, and to the east of about 6 miles. A ridge of white sand, running from the middle of the south boundary of Little towards the northwest corner of that township, forms the divide on the west. Between this ridge and the river for 2 miles north of the south boundary of Little the land is quite swampy and thinly timbered on account of the number of dead tamarack. Part of this area, which was almost entirely tamarack, has a fair growth of hay. From this point north to the falls in the township of Mann, the land is higher and the timber of better quality. For a distance varying from a quarter to half a mile from the river the timber is largely chains wide. The land between this muskeg and another of about the same width diameter. At a greater distance from the river the timber is mostly spruce of 6 or 8-inch size, and when poplar is present it does not average over 10 inches in diameter. On the east side of this sand ridge in lot 9 of the fourth concession of Little there is a muskeg over half a mile in width with 10 feet of peat in the deepest part, which has in part at least a sand bottom. On the east side of this ridge in the first concession of the township there is also a muskeg with about half this width.

For a distance of 2 miles along the south boundary of Little from the southwest corner there is an area of sand covered with small jack-pine, which extends nearly half a mile from the line. On the north and east sides of this area is a muskeg 30 chains wide. The land between this muskeg and another of about the same width west of the jack-pine ridge first mentioned consists mostly of swamp wooded with 7-inch spruce, tamarack and scrubby cedar. This part must be considered of little value for farming purposes, on account of the amount of sandy soil and of muskeg with sandy bottom.

On the east the divide between this part of the basin and that of the Abitibi is formed by an area of sand lying mostly in Calvert township. This is the largest sand area in the region explored. It covers nearly all of the four western lots in the northern half of the township, and part of the east side of the adjoining township of McCart. Granite and greenstone boulders are scattered over the surface in many places, and quite a number of narrow lakes fill depressions in the sand. The soil is of little value, but the area is fairly well wooded with tie-timber, mostly jack-pine averaging a foot in diameter.

Several creeks rise in small lakes in the southern part of this area, or in muskegs adjoining, and flowing west form a creek 50 feet wide in the middle of McCart. A mile farther west this large creek is joined by another which flows in a southerly direction from the northwest corner of the township with a width of 8 feet,

and empties into a lake half a mile long near the junction of the two streams with a width of 20 feet. The combined stream flows west through the second concession near the south end of the lots and enters the Frederick House north of the island in the river, with a width of about a chain.

Good Spruce and Birch

The land drained by these streams is the best timbered portion of the Frederick House basin. Over the whole area the spruce will average 10 inches in diameter, while about the junction of the two streams is a very fine area of birch which will average 18 inches. This grows on two ridges, which are probably moraines, one to the south of the junction and the other between the two streams. The more southerly one has a steep slope to the north and a height of about 60 feet. With the exception of these stony areas the soil is good.

Along the boundary between Little and McCart, there is mixed timber in the second concession, and in the third spruce from 6 to 12 inches in diameter, while the fourth is muskeg, with a depth of 8 feet of peat. A trip inland from the river along the tie-line showed in this part of Little, a narrow margin of poplar and balm, followed by good-sized spruce to the muskeg near the east boundary of the township.

Rocks on the Frederick House

The rocks outcropping along the Frederick House river have been described in a previous report by Dr. Parks.[3] These may simply be enumerated here as follows:

An outcrop of mica schist at Neeland's rapids.
Diorite and a fine-grained schist below the three portages.
A serpentine rock at the three rapids.
Diorite, diorite porphyrite, and a fine gray silicious schist at the falls.

In addition to these the following outcrops were examined within the river basin:

A short distance up the large tributary which enters the Frederick House from the east, there occurs an outcrop of schistose greenstone with glaciated surface, the striæ running S. 10° E., which proved upon examination to be a weathered gabbro.

In the middle of lot 2 on the north boundary of Mann there is an outcrop of hornblende granite, which is badly weathered on the surface.

A weathered greenstone in which aggregates of serpentine and considerable magnetite are plainly seen, outcrops between lots 8 and 9 in the fourth concession of Mann. This is evidently a rock of the same character as that at the rapids, a couple of miles distant, on the river.

At distances of 14, 24 and 40 chains, respectively, on the line running north from the post for lots 2 and 3 in the first and second concessions of Mann, there are low ridges of diorite. The soil between these ridges is stoney, with boulders of augen-gneiss and greenstone scattered over the surface in places.

A ridge of eruptive greenstone, a quarter of a mile in width, crosses Speight's tie line in lot 7, and runs north of the post between lots 4 and 5 on the north boundary of McCart. Samples of a very similar rock were brought in by Mr. Henderson from a high hill on the south boundary of the township in lot 6.

A bluish quartzose schist, rusty in places, and containing pyrite, magnetite, and a white mineral—apparently a product of decomposition—outcrops on the east side of lot 10 at a point 16 chains north of the line between concessions one and two of the township of Little. The strike of this rock appeared to be about N. 10° W. Diorite schist was seen at a point about 30 chains south of the last outcrop, but whether this was in place or only a loose mass could not be determined.

3 Eighth Rep. Bur. Mines, p. 178.

On the Frederick House river between the lake of the same name and Night Hawk lake two outcrops which have not been reported occur on the east bank at distances of two miles above the first and of two miles below the latter lake respectively. These rocks consist of green schist, the one nearest Night Hawk lake containing large crystals of pyrite.

The Abitibi Basin

The basin of the Abitibi differs from that of the Frederick House, mainly in being at a greater elevation above the level of the river. As a result, the creeks tributary to the Abitibi have cut deep ravines to distances from the river varying from 2 to 7 miles according to the size of the stream. This is particularly true of the central part of the basin, where the creeks entering the Abitibi below Iroquois falls have ravines from 60 to 100 feet deep at distances of a mile or more from the river, while the Misto-ogo river and the large creek a short distance to the west at distances of 6 or 7 miles in a straight line from the river have ravines 30 feet deep.

A Well Timbered Region

This, coupled with the fact that the trees are here of greater age, has led to a much better growth of timber than in the parts previously described. The mixed timber, consisting partly of poplar and balm and partly of spruce and balsam, which rarely reaches to more than half a mile from the Frederick House, extends on either side of the Abitibi for an average distance of 3 miles.

The poplar and balm are fine timber of their class. The trees are thrifty, from 60 to 80 feet in height, and sometimes reach a diameter of 3 feet. The average diameter noted varied from 15 to 20 inches. Probably in the portion of the basin covered with this class of timber, 18 inches would be about the average. The spruce grows to a greater height but rarely reaches a diameter exceeding 2 feet. The average diameters noted for this tree varied from 12 to 16 inches, the larger dimensions being found in proximity to the streams. The relative size of the spruce to that of the other timber would be as 15 is to 18. The balsam have a slightly less diameter than the spruce, and a height about equal to that of the poplar. Some cedar grows along the river banks, but it never attains a great height and tapers rapidly from the rather large diameter of 12 to 18 inches at the butt. It will be of little value except for fence posts.

In the southern tier of township from Calvert to Knox there are extensive windfalls, which lessen the value of the timber to a considerable extent. The timber which has suffered most from the violence of the wind is the balsam. These trees are easily uprooted and in some of the more exposed parts almost all are overturned. Where this is the case many of the other trees are either broken off or uprooted, and in some parts only isolated poplar or spruce remain. These open areas are grown up with a tangle of second growth, berry bushes, mountain maple and alder. Travelling across these areas is very laborious, but in season there is many a delicious handful of raspberries, gooseberries and red currants as a reward for the pedestrian's toil.

Good Clay Soil

Over almost the entire basin the soil is a good quality of clay. For the greater part of the three miles on either side of the river, it is well drained by the many creeks which have cut channels at right angles to the course of the river. At a greater distance from the river than this, there are several areas of wet clay land. These areas are not of a less elevation than the well-drained parts; but on account of their level nature the water does not readily flow off them, at least in their present timbered condition.

In the upper part of the basin, between Couchiching falls and lake Abitibi, though the land is comparatively flat, it is well adapted for farming. The poplar and spruce on the north side of the river average about 15 inches in diameter.

The Dokis River

The largest tributary in this part, which is called the Dokis river by some because a hunter named Henry Dokis lives in a log cabin near its mouth, crosses Robertson's base line at 4 m. 30 c. with a width of 20 feet, and flowing north joins the Abitibi with a width of 60 feet near the centre of the township. This stream, which is navigable for about half the distance to the base line, flows through good clay land wooded with 16-inch poplar and balm, and 12-inch spruce.

Another large tributary rises near the southeast corner of the township, and flows north to join the Abitibi about a mile east of the other with a width of 50 feet. A trip to the river a short distance east of this stream showed the presence of large poplar, balm and spruce for the last 2 miles. Two smaller streams which are navigable for only short distances enter, one on either side of the river, about a mile west of the first.

On the point to the east of the outlet of Abitibi lake there is an area of red pine, covering between a quarter and half a section. This is the largest area of red pine in the region.

The shore of the lake about the outlet and for two miles to the northwest is quite sandy. About the head of the bay to the north of this, which is two miles wide, is an area of dry tamarack, which appears to be low and swampy. Between this large bay and the next, four miles to the north, the shore is stony and wooded with mixed timber, with the exception of two small areas of spruce flat about two intervening bays. Between this bay and the point where Galbraith's base line meets the lake, the shore is rocky. Glacial striæ, running S. 15° E., are shown on a small island of greenstone about 2 miles out from the end of the line.

At the north end of the projecting point to the southeast of the line there is a chlorite schist striking west, and a small island of sericite schist off this point. Green schist outcrops near the end of the line and at 41 m. 30 c. there is an outcrop of massive greenstone.

The first three miles north of the Abitibi river along Galbraith's first base line is good clay land wooded with mixed timber of large size, in which there is some windfall. The next 60 chains passes through a muskeg with 8 to 9 feet of peat. North of this is 60 chains of land similar to the first 3 miles. In the northern half of the 50th mile the line crosses a beautiful clear water lake about half a mile in length, which is surrounded on the south and west by a sand area timbered with jack-pine of 12 to 16-inch size. A creek with highly ferruginous water flows from a small quaking bog a short distance north of the lake. The only probable source of the iron appeared to be pyrites in the surrounding sand. The next two miles are of rather poor character as far as soil and timber are concerned. Several low ridges of sand run east and west through spruce swamp, with a sand bottom. These have the appearance of having been formed on the shore of a lake.

Small dips were noted at several points in this swamp, the largest being 12°, but nothing capable of influencing the needle was seen.

The Dokis river flows east along the base line for two miles, then turns sharply to the south along the meridian for over a mile before turning again to the east and crossing that line. It has here a width of 20 feet; but must increase rapidly in size, as it is reported to have a width of nearly two chains where it crosses the base line in the 40th mile. The spruce in this part averages 6 inches, and the poplar where present only 8 inches in diameter. A few large spruce—evidently first-growth timber—occur close to the stream.

Greenstone Ridges

The southeast corner of the township of Knox is broken up by ridges of greenstone which run nearly east and west. Several low ridges cross the meridian for a quarter of a mile on either side of the 43-m. post, while another outcrop occurs at the 44-m. post on that line. Several outcrops also occur, at intervals of half a mile or less, on the south boundary of the township in lots A, 1, 2, 3 and 4. Near the northwest corner of lot 4 in the first concession the same kind of rock forms a hill nearly 200 feet high. Nearly half a mile north of this hill still another outcrop was seen.

This greenstone varies somewhat in the different outcrops, but is evidently one eruptive mass. It contains considerable pyrite near the 43-m. post on the meridian, and stringers of quartz near the 35-m. post on the Base up to this line. In some places it is distinctly schistose, while in other parts no trace of schistosity is seen.

The soil is composed partly of low sand ridges and partly of level clay land. The 36th mile on the base line in almost entirely clay, wooded with large mixed timber. A photograph was taken of some fine poplar in this mile. The other miles along the meridian and base lines are more broken, but there is some good land in each. The two miles of country between this rocky area and the Abitibi, with the exception of a small area of sand surrounding two little lakes on the meridian, has a good clay soil and is wooded with marginal timber of large size.

In the first mile north of the greenstone hill in lot 4 there is considerable balsam windfall.

A large creek flows from this area in a northwesterly direction to join the Abitibi in lot 5. Where crossed at a point one mile distant from the river, it flowed in a ravine 30 feet deep and had a width of 12 feet.

A second creek, identical with the last in respect to size and depth of ravine flows from the eastern side of Rickard township, and joins the Abitibi in lot 11 of Knox. The first two and a half miles south from the river are marginal in character, and the remaining 2 miles to the boundary are level spruce land. The soil is clay throughout. The presence of rounded stones and gritty material within the clay at a distance of half a mile from the river, points to part of it at least being of glacial origin.

On the south town-line of Rickard, the first mile east of the centre is mostly muskeg with a depth of 8 feet of peat. From the middle of this mile north to the Abitibi at the foot of the Crooked rapids the country is similar to that on the east of the township. The spruce in the first 2 miles is somewhat larger, varying from 6 to 12 inches in diameter, and in the next mile and a half the windfall is more extensive than on the eastern side of the township.

At this point a ridge of greenstone, running east and west, was crossed, and from here to the river the timber is very large, the poplar averaging 20 inches and the spruce 16 inches in diameter. About a quarter of a mile below these rapids, a creek of 20 feet enters the Abitibi on the south side. This creek has produced a ravine of much greater depth than the other tributaries above. In the bed of this stream at a distance of 8 chains from the river another outcrop of greenstone occurs.

On the west side of Rickard a ridge of glacial material extends, from lot 10 in the first cocession, across the meridian in the fourth mile and the Abitibi river in the northeast corner of Teefy, into the township of Edwards for a distance of over a mile. There is a narrow lake, half a mile in length, with an outlet to the southwest at the south end of the ridge. That this ridge, which is quite low at this point, has along the meridian a height of about 70 feet, is shown by the depth to which a small creek which drains two or more small lakes has cut through the sand. This is the only point where anything like a cross-section of one of these ridges could be obtained. The eroding action of the stream has produced a ravine with exceedingly

steep sides composed almost entirely of white sand. The underlying clay now forms the bed of the stream. The width of the ridge varies from a few chains at the south to over half a mile at the north end.

South and west of the lakes along the meridian the timber is second growth, but over the remainder of the area there is a growth of jack-pine, spruce and birch of fair size. To the west of the ridge the soil is clay, timbered with spruce and poplar, some of which reaches a diameter of over 2 feet. The south half of lot 9 in the second concession is mostly muskeg; but for the $3\frac{1}{2}$ miles north of the Abitibi the land is all high, with a good clay soil and mixed timber, with an average diameter of 12 to 16 inches. Along the river bank, which is at this point from 70 to 80 feet high, considerable balm accompanies the poplar and spruce. In what would be lot 9 in the third concession, after the subdivision of the township, there are two outcrops of pyritiferous greenstone, much resembling the rock on the Abitibi at the Two Portages.

Tributaries of the Abitibi

Next to the Black river, the two largest tributaries of the Abitibi enter that river from the north in lot 9 of the sixth concession of Rickard. The larger of these is known as the Misto-ogo river, and has been described by Mr. Coulthard.[4] The other, which enters the Abitibi some 20 or 30 chains below the mouth of the Misto-ogo, has not been previously described. Both have their source in the country north of Galbraith's base line, the Misto-ogo to the northeast of the farthest corner of Wesley, and the other to the northwest of the northwest corner of that township.

The Misto-ogo river crosses the base line a little east of the middle of the 31st mile, and enters the township of Wesley about one mile south of that line with a width of 40 feet. About a mile down from this last point it is joined by a creek 12 or more feet wide, which flows from the west. The river is navigable for canoes as far as this point, that is, to within about 2 miles of the base line, and by dint of much lifting over driftwood, the line itself may be reached. It was crossed, in what would after subdivision be lot 9, at a distance of 2 miles and a quarter from the south of the township. It was here flowing west in a ravine at least 40 feet deep, and had a width of one chain and a depth of 4 feet.

The more westerly creek crosses the same base line near the middle of the 23rd mile, with a width of 15 feet. It flows southeast in a beautiful valley about 10 chains wide and 30 feet deep, and crosses the meridian near the 11-m. post.

A creek 10 feet wide, which crosses the meridian 12 chains south of the 10-m. post, forms a junction with the main stream about half a mile to the east of this line, and from this point to its mouth the course of the stream is nearly south. A traverse of the lower $2\frac{1}{4}$ miles as far as a log jam indicated that the general course of this part of the stream was a few degrees east of south. The depth of water in the lower part is from 1 to 3 feet; and the width is one chain. Above the log jam there appeared to be a considerable narrowing of the stream. At a distance of half a mile from the mouth there is an outcrop of greenstone on the right bank at the water's edge.

The portion of the Abitibi basin drained by these two streams may be divided into three parts: (1) a river marginal portion in the southwest of Wesley township; (2) a portion which is grown over with second-growth timber reaching diagonally across the township in a northwest direction, and a third portion, consisting largely of spruce woods, in the northeast of the township.

The river marginal portion extends along the west boundary of Wesley from the Abitibi river to the middle of the township. Four miles east of this it extends only one mile into the township, or to a little over 2 miles from the river.

4 Report of Survey and Exploration of Northern Ontario, 1900, p. 45.

The area of second-growth timber reaches to the Abitibi, from the bend in the river at the island portage to a point a short distance east of the township of Wesley. It has here a width of 2 miles, stretching inland to a muskeg in the second mile on the east side of Wesley. It extends with a nearly uniform width across the middle portion of the Misto-ogo valley, and along the two branches of the more western stream beyond the base line. This area was burned over about 35 years ago, and the oldest trees are therefore about 30 years of age. Along the streams the timber growth consists almost entirely of small poplar, usually from 1 to 5 inches in diameter. In a few places, however, trees of 10 inches were seen. The valley mentioned in the northeast corner of Edwards and the surrounding parts contain only a very few scattered poplar and spruce, and are in their present condition almost ready for the plow. Some of the land along the Misto-ogo is hardly less open. These areas are mostly grass-covered. The other extreme however is reached in those portions removed from the streams. These are quite level, and for the most part grown over with a thicket of small spruce, alder and tamarack, through which it is almost a burrowing operation to pass.

In the upper portion of the Misto-ogo basin, the timber along the streams consists of poplar, spruce and balsam. The largest timber grows along the creek which flows east at a point one mile south of the 28-m. post on the base line, and has already been described. The poplar here averages 18 inches and the spruce 15 inches, and this is at a distance of 6 miles from the Abitibi. But over the greater part of this tract the timber consists almost entirely of spruce from 6 to 10 inches in size.

The soil over the whole of this region is clay, with the exception of a few narrow muskegs within the areas of spruce woods. Good drainage is secured to almost the whole by these two large streams and their branches; while, as has been pointed out, some parts along these streams could be cleared with little difficulty.

Effects of Imperfect Drainage

The greater part of the township of Edwards, and the northeastern part of Aurora, is typical of those areas situated at such a distance from the river that few or no streams have cut ravines through them. A muskeg with a depth of 5 to 6 feet of peat at a distance of half a mile from the edge occupies the greater part of what would be after subdivision, lots 4 and 5 in the second, third and south half of the fourh concessions of the township of Edwards; while another occupies lot 9 in the fifth concession. In these muskegs several streams take their rise, and flow, through flat clay land wooded with spruce, on the one hand east to the large creek in the region just described, and on the other southwest or west to the Abitibi river. One of these flows northwest from the muskeg in the fifth concesssion and crosses the base line in the 19th mile with a width of 8 feet. Two creeks, each 6 feet in width, which flow through spruce woods near the middle of the line between Edwards and Aurora, unite half a mile to the west, to form a creek 10 feet wide, which flows west to the Abitibi in a ravine 20 feet deep. Another of the same width flows south in lot 9 through the first two concessions of Edwards in a ravine, increasing in depth to 30 feet at the town-line of Teefy, and to 60 or more in that township before joining the Abitibi river below Iroquois falls.

Along these creeks some poplar is usually present with the spruce, but over the central portions of the area the timber is mostly spruce averaging from 8 to 10 inches in diameter, accompanied by some balsam on the higher parts, and by dry tamarack where the land is very level.

The soil is clay throughout the area. In the spruce woods it is covered with one to two feet of moss and mould. But in the parts where tamarack is also present, though the land may be quite wet, only a few inches of moss covers the soil. Whether this is a natural condition, or the result of the sun's rays gaining access to the ground since the killing of the tamarack, is not easily determined, but I am inclined to think the latter is the case.

Rock Outcroppings

Several outcrops of greenstone and of green schist occur within this area. A low hill of green schist crosses the base line a quarter of a mile west of the 22-m. post. The rock, which has a strike north and south, and a dip nearly vertical, contains small masses of quartz, which have been pressed out by the shearing action that gave the rock its structure.

Running S. 18° W. from a point nearly 2 miles south of the 19-m. post on the same line, there is a dike of granite 10 feet wide in mica schist or Huronian gniess, with pyritiferous greenstone on either side. This dike was noticed at two points nearly 2 miles apart. At the more northerly point no gneiss was seen, and the dike of granite formed the east side of a ridge of the same greenstone.

At a point 2 miles north of the post on the townline of Teefy for lots 8 and 9, there is a hill about 100 feet high composed of green schist or a schistose greenstone, and at a point 30 chains east of this hill an outcrop of greenstone—probably a diabase.

Teefy, Calvert, Aurora

As a whole the township of Teefy is perhaps the best wooded in the region. Practically the whole township is timbered with poplar with an average diameter of 18 to 20 inches, spruce with an average diameter of 12 to 15 inches, balsam and birch. The soil is good, but somewhat cut up by ravines. A branch of the one previously mentioned in the northeast corner of the township has in lot 8 of the sixth concession a depth of about 60 feet. On the east side of the township, both above and below the Two Portages, there are several others, not however so deep. In the southern part of the township, the timber has suffered considerably from wind storms.

The same is true of the southern part of Calvert, at least along the line between concessions two and three for the first two miles. The third mile is mostly muskeg with 5 feet of peat, and the fourth spruce woods with 8-inch timber.

In the northern part of Calvert the timber is of better quality, and unaffected by windfall. For a distance of 4 miles west from Iroquois falls, the timber consists of poplar, spruce, balsam and birch of about the same size as in Teefy, and the soil is of the best quality of clay. On the east side of lot 3 a ravine nearly 100 feet deep has been cut across the fifth concession by a creek 10 feet in width. On the opposite side of the Abitibi, a creek of equal width has cut a ravine 50 feet deep across the sixth concession. The land along this creek and for a distance nearly 2 miles east is wooded with mixed timber of smaller size than on either side of the river at Iroquois falls. Along the line between concessions five and six, the first mile only to the west is good land, the sand area being reached at this point.

On the west side of the deep ravine where it crosses the line between concessions four and five a rock consisting mostly of hornblende, forms an almost perpendicular wall. Along the same line north of the post for lots 8 and 9 there is a ridge of pyritiferous greentsone; and at the post one mile north of this is a hill of greenstone about 150 feet high. About the edges of this hill the greenstone is distinctly schistose.

The central portion of the township of Aurora is distinctly lower than the districts which have just been described, the ravines having here a depth of only about 20 feet. East of the Abitibi in the second concession, the marginal timber extends only to a distance of one mile from the river, and even in this mile spruce predominates. Two miles of 10-inch spruce succeed this to the east. West of the river along the line between concessions one and two, there is mixed timber with spruce predominating, for a distance of 2 miles, to a large muskeg in the 8th mile on the meridian line. This muskeg extends across the concession line with a width of 30 chains, while another occupies the first half mile north of the corner post of the township.

The country 2 miles west of these muskegs may be described as wet clay land, with tamarack windfall and alder. The timber is of little value, it having been an area of tamarack, which is now all dead.

East of the small rapid two miles above Buck Deer rapids, there is only half a mile of marginal timber. Spruce, of an average diameter of 8 to 10 inches, is the principal timber as far as the ridge of greenstone in Edwards, where there is some stony land wooded with birch, balsam and other timber. North and east of Buck Deer rapids the country is higher, and is wooded wih large poplar, balm and spruce for a distance of 2 miles. In the 16th mile along the base line the timber is of the same kind, but of smaller size, the spruce averaging from 6 to 8 inches. The 17th mile is mostly muskeg, a sounding showing a depth of 4 feet of peat.

Buck Deer Rapids Area

Lastly, the country west and southwest of Buck Deer rapids will be described. This land is drained by a creek, which crosses the meridian line with a width of 12 feet, at a point 20 chains north of the 11-m. post, and enters the Abitibi about half way between the rapids and the base line. This creek takes its rise in the southwest corner of Newmarket, and flows diagonally acress the township. Where it was crossed, at a point 2 miles east and half a mile north of this corner of the township, it had a width of 5 feet, and a bank 10 feet in height. The country for a mile south and for half a mile north was wooded with 12-inch spruce, poplar and balsam, and had a good clay soil. This was followed to the north by half a mile of spruce, when the large muskeg—over two miles across at this point—was reached. A lake nearly 60 chains long and one-third as wide lies near the south east end of this muskeg, and it is probable that a stream flows east from this lake to join the creek last mentioned. A sounding made in this muskeg showed a depth of peat of 11 feet, which is the greatest in the region.

For a distance of one mile west of this creek, in the second and third mile south of the base line, the timber is large, some of the spruce measuring 26 inches in diameter. It consists of red and white spruce averaging 12 inches, balsam, birch and poplar. The area of second-growth in the northeast corner of Mann extends over two miles east into Newmarket in the second mile south of the base line. The first mile north of the muskeg, and the middle of the township at a distance of one mile from the base line is timbered with 8-inch spruce. To the east of the tract of large timber along the lower part of the creek is an area of excellent farming land covered with second-growth. In the 11th mile on the meridian, the poplar has grown to a size of 12 inches, and the spruce to one of 8 inches; but over most of the area it is too small to be of value; consisting of 6 to 8 inch poplar and balm and brushy spruce of smaller size.

The soil over this area is a clay of good quality, and in all the northern part is sufficiently dry to be well adapted for farming. In the beds of the streams pebbles of greenstone, granite and shale were noted; and in a deep ravine at the northeast corner of Newmarket some interesting concretions composed of clay were seen. At a point 2 miles east and the same distance south of the northwest corner of Newmarket there is an outcrop of granite, the only rock seen in the area.

Rock Outcrops on the Abitibi

The rock outcrops on the Abitibi river have mostly been described in previous reports: those below the Two Portages by W. A. Parks,[5] and W. J. Wilson;[6] and those between the Two Portages and Abitibi lake by Wilson, Baker and Coulthard.[7]

[5] Eighth Rep. Bur. Mines, p. 181. [6] Geol. Sur. Can. Sum. Rep., 1901.
[7] Report of Survey and Exploration of Northern Ontario, pp. 29 and 46.

Little will be said about the outcrops described except to define their location more accurately. On an island at the foot of Buck Deer rapids there is an outcrop of greenstone—probably a dike—with glacial striæ S. 5° W. The rock at Buck Deer rapids has been described by Dr. Parks as hornblende gneiss, and that at a constriction in the river near the middle of the township as gneissoid granite.

About half a mile below this last outcrop, a red biotite granite was noted near the water's edge on the left bank. Another outcrop of granite occurs on the right bank about the middle of the first concession of Aurora.

About the corner of lots 2 and 3 in concessions five and six of Calvert, which comes in the river, there are several outcrops of granite and gneiss reported upon by Mr. Wilson.

Three-quarters of a mile above on the right bank there occurs a very hard silicious green rock, with smoothly glaciated surfaces, containing a dike of granite about a foot in width, with stringers of the same running into the darker rock. The eruptive contact of the Laurentian occurs between these two points, but could not be more accurately located.

The next outcrop above occurs on a small island near the right bank on the east town-line of Calvert, and consists of schistose greenstone.

On the same bank, just above the line between concessions four and five of Teefy, there is a dike of felsite 9 feet wide running north and south, and a 3-inch vein of glassy quartz in massive greenstone.

Between Iroquois falls and the Two Portages, in addition to the green schist where the river first crosses the south town-line of Teefy, which has been noted, there are two outcrops, one on the right bank in the south part of the third concession consisting of similar rock, and the second of quartzite with glacial striæ S. 20° E. on the same bank half a mile below the lower of the two portages.

Above the barrier of weathered pyritiferous diabase at the Two Portages, there are at least three outcrops of massive greenstone, the last a short distance above, and the middle one at a small rapid in the fifth concession of Teefy.

At the next rapid a short distance above the meridian line, the greenstone is distinctly schistose.

At the 7-chain portage on the left bank at the crooked rapid, a weathered greenstone was examined, and a short distance up stream a similar rock was seen on the same bank.

On the island portage—8 chains in length—at the next rapid, green schist and a bluish gray silicious schist containing veinlets of quartz occur.

About lot 8 in the township of Knox, there is an outcrop of greenstone on the north bank of the river, and half a mile east another, somewhat schistose in structure.

On the south bank in lot 5 two bluffs of greenstone about 15 chains apart occur.

The rock at the rapid about half a mile below the meridian line is a much-weathered quartz porphyry, gray in color.

At Couchiching falls, and at a point on the north bank half a mile below, the rock consists of a hard fine-grained greenstone.

No outcrops occur above the falls until within half a mile of the lake, where there is a dark-colored hornblende-biotite granite on the north bank. This is probably a dike striking N. 30° W., as it is badly weathered along planes in that direction.

III. RESOURCES OF THE REGION

The Soil

The principal asset of the region is its soil, samples of which have been taken by Mr. Henderson, and will be dealt with in his report. As has been pointed out, the soil over almost the entire area is clay of good quality. The sand areas are so small as to be a benefit, rather than a detriment, to the region, considered as a whole.

The district is at present rather subject to summer frosts. Two occurred this year, one on 23 July, when the temperature recorded was 26° F., and the other on 31 August, when it was 27° F. These seem to have been unusually severe, as no frosts were reported by Mr. Kay between 17 June and 1 September last year. The large amount of moss-covered land which retains the frost until late in the summer is no doubt largely responsible for these frosts, and the clearing of the land, which would admit the sun's rays and result in the killing of the moss, would raise the average temperature several degrees, and make these frosts very rare or do away with them entirely.

On account of its distance from the railway—150 miles in a straight line, or 200 by canoe—this region has been generally considered a more northern one than it really is. The highest latitude reached this year is just about the 49th parallel, so that the whole of the region lies to the south of the most southern point of Manitoba.

The areas best adapted for settlement are, the Abitibi basin, for an average distance of 3 miles on either side of that river, the basin of the Frederick House, for a width of 2 miles on either side of the river, the basin of the Mattagami river, for a rather less width, and the parts adjoining the main tributaries of these rivers at greater distances from them than those mentioned.

The drainage of these areas is secured by the numerous ravines, which have been eroded to distances of 2 or 3 miles from the river. It is probable that the clearing of the land, alone, will add considerably to these areas.

The streams are young, as shown by their V-shaped valleys; and, as in other parts the removal of the forests will lead to a cutting back of these ravines to much greater distances than they have reached at present. The areas farthest removed from the rivers, such as the spruce land in Prosser and Tully and in the southern part of Wark and Gowan, parts of the next four townships to the north of these, portions of Newmarket and McCart, the township of Edwards, and the township of Moody will require artificial drainage. None of these areas however are more than 4 to 6 miles distant from streams, with valleys of considerable depth, and with anything like the efforts that have been made to drain many parts of older Ontario, even the muskegs would be turned into arable land.

Building Materials

The timber available for lumber consists of spruce, poplar and balm. The spruce only is suited for lumber for outside use. Poplar and balm could be used where not exposed to the weather. The jack-pine growing on the sand areas is of a size suitable for making railway ties. The dry tamarack standing in many parts will also provide suitable tie timber.

The only stone available, besides loose material of this kind, which is not plentiful, is the eruptive greenstone forming the isolated hills in the region. Gravel for concrete masonry and sand for mortar could conveniently be obtained in almost every part of the region, from the glacial ridges. Sand of good quality is to be found in the fourth mile on the line between Teefy and Rickard. Ballast for railways is to be found in the same ridge, in the sand area in Calvert township, and at the north and south ends of the ridge west of the Frederick House river. Clay for brick-making is plentiful in every part of the region. That along the Frederick House in the township of Little was found to bake readily.

Timber

The only red or white pine, other than the small area near the outlet of Abitibi lake, is a small clump at the falls on the Frederick House and a few scattered trees on some of the ridges. There is no timber for export as lumber. The local require-

ments will consume all the spruce or other timber large enough for manufacture into lumber. But in the large areas of spruce, the country possesses resources which can be marketed as pulp, once mills are established on the rivers. The facilities for driving the pulpwood are fair. The difficulty lies in the driftwood which blocks all but the largest tributaries at a short distance from their outlets into the main rivers. Most of this could be cut out or drawn out; but some of the jams on the larger streams would require the use of dynamite.

Water Powers

The most easily developed water-power in the region is situated on the Frederick House river in the township of Mann about a quarter of a mile from the south town-line. These cascades have, according to Dr. Parks, a fall of 46 feet. The rocky barrier which rises only a few feet higher than the level of the water above the falls, has a width of a little over 200 feet. An excavation of this length on the right bank will make available the full height of the falls.

In the fifth concession of the same township on the same river, two chutes 5½ feet and 2 feet in height, respectively, and only a few chains apart are separated by 5 chains of smooth water from a rapid 30 chains in length, with a fall, as given by Parks, of 14½ feet. This provides, in a distance of about half a mile, a total fall of 22 feet. This drop might be taken advantage of for power purposes, by building a dam about 100 feet in length across the river near the foot of the rapid.

On the Abitibi river three water-powers are available within the region explored. The largest of these is at Couchiching falls, where the river drops about 30 feet in two successive cascades over a barrier of hard greenstone. These cascades are followed by about a quarter of a mile of very rough rapid. The total fall is given by Wilson as 46 feet, and by Baker as 45 feet (by aneroid). In order to take advantage of the total drop, a great deal of excavating would be necessary, and even to utilize the main drop for power purposes would require an excavation between 300 and 400 feet in length, unless the power house was built over the lower of the two cascades. A central mass of rock which divides the stream laterally would materially aid in this.

At the Two Portages on the Abitibi a second water power could be secured. The lower portage is past a cascade with a drop of about 9 feet; while the upper, 100 yards distant, is past a rough rapid with a fall of about 6 feet. Advantage could be taken of the lower fall for power purposes, by building the power house over either of the two main gaps or over a small western gap; but to secure the total fall of 15 feet, a dam about 150 feet in length would have to be built at the lower fall.

At Iroquois falls in the fourth concession of Teefy township, there is another water power which could be easily developed. At this point there is a vertical drop of 15 feet, while in the first two chains from the brink there is an additional drop of about 2 feet. The stream is divided above the falls into three parts by two islands. The western and central streams take the greater portion of the volume of water. By building a coffer-dam to shut off the water from either of these channels, turbines could readily be put in place at the brink of the fall and power secured.

In view of the fact that the country contains so much spruce and poplar suited for pulp making, these water powers are of prime importance. Even with the building of the additional 100 miles of the Temiskaming and Northern Ontario railway necessary to tap the southern part of this region, it is a question if this spruce could be profitably shipped out as pulp-wood in competition with the spruce of the Blanche valley 100 miles to the south; but with the building of mills at some of these points where power can be secured, the expenses of any long freight haul would be eliminated.

As the measuring instruments at our disposal for determining the area of a cross-section of these streams were rather crude, and as surveyors engaged in the neighborhood of Iroquois falls and the first falls on the Frederick House spoke of

estimating the water power at these points, it was not thought advisable to make sections and obtain approximate results as to the energy capable of development. The volume of water in the Abitibi above Couchiching falls has been estimated by W. J. Wilson of the Dominion Geological Survey, who made a section at this point, as 306,000 cubic feet per minute. On this basis the horse-power available at these falls is about 16,000, without taking into consideration the rapids below the main fall. The power available at Iroquois falls, and at the first falls on the Frederick House would be in each case at least half of the above.

Muskegs or Peat Bogs

It is possible that, with the advances which are being made in the manufacture of peat-making machinery, these may prove a valuable source of fuel, but it will likely be in the country still farther north where they are more extensive, that peat manufacture will be carried on to the greatest extent. The largest of these, in the townships of Wark and Gowan, has an average width of a mile and a quarter, and a length of about twelve miles. This represents an area of nearly 10,000 acres, with an average depth of peat of 6 or 6½ feet.

The second largest, in the township of Newmarket, has an area of about 2,500 acres, the greatest depth of peat being 11 feet. The muskegs in the townships of Edwards and Moody are about the same size and have together an area of 2,500 acres. This makes a total area of 15,000 acres or about 1½ per cent. of the area of the region. Adding another 1½ per cent. for the areas of smaller muskegs, the total area of muskeg within the region may be put down as three per cent. of the whole.

Below will be found analyses of some samples of peat, made by Mr. A. G. Burrows, Provincial Assayer, Belleville.

Locality and depth.	Water.	Volatile Combustible.	Fixed Carbon.	Ash.	Remarks.
	Per cent.	Per cent.	Per cent.	Per cent.	
29 m. post Patten's Meridian, 2 ft. down......	11.28	57.36	23.08	8.28	Yellowish green ash
North of Abitibi River from mouth of Dokis River, 2 ft. down..........................	8.72	65.52	21.04	4.72	Yellowish ash
2 m. 50 c. north of 4 m. post Patten's first base line, 1 ft. down...........................	9.42	66.96	18.14	5.52	Yellowish ash

A sample of marl from the bottom of a small lake north of the northern arm of the Montreal river on the canoe route to Night Hawk lake, analysed by Mr. Burrows contained:

	Per cent.
Insoluble residue	11.14
Lime	36.36
Magnesia	.60

A specimen of pyrites from the west bank of the Montreal river two miles below Fort Matachewan, was found by the writer to assay $1.50 per ton in silver.

IV. PETROGRAPHY

The greater part of the region has been mapped as Huronian. In this part basic eruptives are the most commonly occurring rocks. Almost all stages of alteration of these rocks are to be seen. Some are sufficienty fresh to be classed as gabbros, diorites, and diabases; others which have been classed as schistose greenstones and green schists, though considerably metamorphosed, show undoubted igneous origin, while in others the metamorphism has been so great that no trace of the original rock remains, and they can only be classed according to their principal constituent, as chlorite, sericite, or other schists.

No rocks of sedimentary origin were encountered. A rock outcropping on the right bank of the Abitibi below the Two portages, which in the field was thought to be a quartzite, appears when examined microscopically to be a much altered ash rock, containing a great deal of leucoxene and some feldspars.

Quartz porphyries outcrop at the Sandy Portages on the Mattagami, and at the first rapid below Couchiching falls on the Abitibi. The only other acid rocks are a syenite near the junction of the two main creeks east of Patten's meridian, and a similar rock reported by surveyors about the sixteenth mile on that line.

In the V-shaped Laurentian area, the apex of which reaches to within a mile and an half of Iroquois falls, the rocks are mostly gneisses and granites with a few mica schists and greenstones.

The contact has been located by Dr. Parks on the Frederick House river at Neelands rapids, and at the point mentioned on the Abitibi by Wilson. At no point has a clearly defined line of contact of the two rocks been established. A dike of granite 1 foot wide in altered greenstone, on the right bank of the Abitibi between lots 1 and 2 in the fifth concession of Calvert township, must be very near the line of contact. To the northeast of this point the contact has been placed near the 10-foot dike of granite in greenstone which crosses lots 10 and 11 in the fourth concession of Edwards, with a direction N. 10° E. To the northwest of the apex the line of contact has been plotted, cutting off the southwest corner of Aurora and passing south of the granite outcrops in Newmarket and in the middle of lot 2 on the north boundary of Mann, in a fairly straight line to Neelands rapids on the Frederick House. To the west of this river no outcrops were seen; and as a consequence, it it could not be determined whether or not the line of contact continues to the westward as plotted on previous maps. Another V-shaped projection may be represented by the syenite mentioned above.

Gabbros

From the microscopic study of a number of thin sections, these seem to be the most commonly occurring basic eruptives. A specimen from the right bank of the Abitibi half a mile below the outlet of Abitibi lake, consists principally of augite, hornblende, plagioclase and orthoclase. From the angle of extinction, the plagioclase feldspar is seemingly andesine in part at least. Quartz crystals are present in small amount. Biotite occurs as a secondary constituent; while crystals of apatite and magnetite are present as accessory constituents. The micro-structure is distinctly idiomorphic.

The gabbro from near the mouth of the large creek which joins the Frederick House 1½ miles above the point where it crosses the district line, was found to consist of augite, plagioclase feldspar, and secondary chlorite.

A greatly weathered specimen from lot 5 in the third concession of Tully consists largely of decomposition products, chlorite, serpentine, kaolin and calcite being all present. Remains of the augite crystals are however plainly to be seen, and small but well-formed crystals of plagioclase with an angle of extinction corresponding to bytownite. Pyrite is present as an accessory constituent.

Diabases

The best preserved specimen is from near the middle of the 42nd mile on Galbraith's base line. It is idiomorphic in structure and consists of augite slightly weathered to hornblende, plagioclase with an angle of extinction of about 20°, and biotite in small amount. Considerable magnetite is also present in this rock. Specimens from the Two Portages and elsewhere were found to be much altered by weathering.

Peridotites and Picrites

The serpentine rock which outcrops on lot 9 in the third concession of Mann, and on the Frederick House river at the Three Portages, is most interesting in thin section. Besides the serpentine which is the chief constituent, considerable magnetite, and some orthoclase are also present. Under crossed nicols the shape of olivine crystals with characteristic net structure due to weathering can be distinctly seen, but the olivine has been almost enirely weathered to serpentine. This points to the rock being an altered peridotite.

A schistose greenstone from lot 8 in the third concession of Prosser consists largely of serpentine aggregates, and chlorite, with pyrite in subordinate amount. Remains of crytsals of olivine and augite imply that this rock is a greatly weathered picrite.

Diorites

A greenstone from the west side of lot 2 in the second concession of Mann was found to consist of hornblende, biotite, plagioclase, quartz and magnetite. Hornblende, which is the chief constituent, is present in large crystals, and also in small needle-shaped crystals within the quartz. The rock is best described as a quartz diorite.

Diorite porphyrites, which have been described by Dr. Parks, outcrop along the Frederick House river, near the north and south town-lines of Mann. These rocks contain large crystalline aggregates of plagioclase feldspar in a diorite ground-mass.

A greenstone outcropping 2½ miles east of 14 m. 30 c. on Patten's meridian may best be described as an altered diorite. Chlorite and serpentine are both present in considerable quantity, the first distinguishable by its dull polarization colors and parallel extinction. A mineral with high double refraction appears to be epidote, formed from decaying feldspars. A completely weathered white mineral gives the rock a poikilitic structure.

Schists

The schists, which include hornblende, chlorite, sericite and quartzose schists, are found in the southern part of the district.

Most of the green schists consist principally of hornblende and chlorite and contain pyrite, magnetite, or even hematite as accessory constituents. The best example of chlorite schist is from the shore of Abitibi lake, about one mile east of the end of Galbraith's base line. The only sericite schist examined outcrops on a small island near by.

A light-colored rock which outcrops in association with green schist below the Two Portages, though resembling a quartzite, appear under the microscope, as a much altered ash rock. It consists largely of leucoxene with small quantities of feldspars, chlorite and possibly quartz.

Schists containing considerable quartz outcrops in the southern parts of Little and Prosser. These are greatly stained by limonite.

The garnetiferous biotite schist at Neelands rapids was the only sample examined from the Laurentian portion of the region.

Porphyries

Two quartz porphyries were noted, one outcropping as a dike at the first rapids below Couchiching falls on the Abitibi, and the other at the upper rapids at the Sandy portages on the Mattagami. The first contains phenocrysts of quartz in a badly weathered ground-mass. The second is porphyritic in structure when examined in thin section, with an unusually large proportion of the constituents crystallized out from a devitrified ground-mass. Crystals of quartz and orthoclase are distinctly

seen under the microscope, and others which appear to be of plagioclase with an angle of extinction of about 15º. The fine-grained nature of this rock causes it to resemble a quartzite in the field.

Granites and Gneisses

These rocks of the Laurentian portion of the region are the only ones of an acid nature besides the few quartz porphyries and syenites which occur as dikes in the Huronian. The gneisses, which are indistinctly banded and similar in composition to the granites, might be described as gneissoid phases of these rocks. The granites include hornblende and biotite varieties. The scarcity of outcrops, excepting along a short portion of the Abitibi, made it difficult to secure fresh specimens.

One of the best preserved specimens from the bank of the Abitibi near the post for lots 2 and 3, concessions V and VI of Calvert, is composed of orthoclase, quartz, hornblende, and plagioclase, and is distinctly porphyritic in structure. The hornblende, which is composed in part of twinned crystals, can be seen changing to biotite. Secondary kaolin has also been formed from the decay of the orthoclase, and apatite crystals are present as an accessory constituent.

In closing, I wish to thank Dr. Coleman and Dr. Walker of the University of Toronto, for assistance in the study of the rocks described.

AGRICULTURAL RESOURCES OF ABITIBI

BY ARCHIBALD HENDERSON

In May, 1904, Mr. T. W. Gibson, Director of the Bureau of Mines, instructed the writer to accompany, in the capacity of agriculturist, Mr. J. G. McMillan, B.A. Sc., in an exploratory survey of that part of the northern clay belt lying between lake Abitibi and the Mattagami river.

We set out in two canoes on the west branch of the Spanish river at Matagama siding, on the Canadian Pacific railway, in the early morning of June 1, and seven days later the scene of our explorations was reached. Work began on June 9 in the country between Murphy township and the Mattagami river. The last camp from which overland trips were made was on the Frederick House river about four miles below milepost 157 on Niven's line. The homeward paddle started from here on September 24, the Temiskaming and Northen Ontario railway being reached at the point where it intersects the Montreal river on Monday morning, October 2. Thus four months were spent in the north country.

THE TERRITORY EXPLORED

The district with which this report is concerned is roughly one thousand square miles in extent, *i. e.*, about twenty-eight townships. It includes the townships of Wark, Gowan, Prosser, Tully, Little, Mann, McCart, Newmarket, Calvert, Aurora, Teefy, Edwards, Rickard, Wesley, Knox and Moody; the unsurveyed area between the eastern boundaries of Knox and Moody and lake Abitibi, which is approximately equivalent to two townships; the unsurveyed area between Murphy and the Mattagami river, roughly one township and a half; an unsurveyed area northwest of Prosser, one-half a township; six townships north of Prosser and Tully; and two townships north of Mann.

This country was explored by overland trips, two or three miles apart. Notes were made at the end of each mile, recording in chains the length of each of the various types of surface as I shall describe them. Here and there samples of soil for future chemical and physical analysis were taken. I am enabled thus to present a report on the whole district and on each township, stating in both cases an estimate of the proportional area of each of the various types of country.

The report of the work accomplished is presented under the following headings:

I. Soil and Timber.
  (a) General Description.
  (b) Description of Townships.

II. Climate.

III. Flora.

IV. Fauna.

V. Conclusions.

VI. Appendix.
  (1) Results of Chemical Analysis of soil samples by Prof. Harcourt.
  (2) Results of Physical Analysis of soil samples by Prof. Reynolds.

I. SOIL AND TIMBER

(a) General Description

For the sake of avoiding repetition, and also for the benefit of those who wish only a general idea of the soil and timber of this region, I shall describe the types of area of which it is composed, and refer to their relative proportions. Afterwards, I shall describe individually the townships explored, giving the percentage of the various types present in each, and other details.

The types of country are as follows: (1) Black Spruce Forest; (2) River Bank, (3) Poplar Knoll; (4) Muskeg; (5) Jack-Pine Plain; (6) Rock.

(1) BLACK SPRUCE FOREST

Over half—about 59 per cent.—of that part of the Clay Belt explored is covered by a Black Spruce forest. The subsoil is mostly wet clay and clay loam overlying which are from one to four feet of rich black mould, which, when mixed with the clay by cultivation, will make a good soil for farming purposes. Above this again, are from six to twelve inches of moss, mostly a species of sphagnum. Many areas are drier in nature, waterpools being infrequent, and the surface not so flat as is usually the case. The soil in these is often of a lighter nature, being a sand loam in some cases. It is covered by only a few inches of decaying organic matter, on which many bryineous mosses thrive.

As the name of this type of area indicates, the predominant forest tree is the black spruce (*Picea nigra.*) This tree varies very much in size, attaining a diameter in some areas of fifteen inches, but averaging from eight to ten, and having clean boles from forty to seventy-five feet in height. Its growth is a slow one, the eight-inch tree often being about one hundred years old.

The next most prominent tree is the tamarack (*Larix Americana*). This tree is thinly scattered throughout the spruce woods, but in some of the very wet localities it becomes the predominant timber constituting the so-called tamarack swamps. Unfortunately, the tamaracks of this region are now all dead, having been killed within the last few years by the larch saw-fly. In the tamarack swamps there is a dense undergrowth of hoary alder (*Alnus incana*), which makes "travelling" in these localities exceedingly difficult. Many of the tamarack, ten to fifteen inches in diameter, are as yet perfectly sound and would make good railway ties, for which purpose such timber has been utilized in the Temiskaming country.

The balsam (*Abies balsamea*) is also found almost everywhere throughout the spruce forest. The trees, however, are usually small, both in diameter and height, and are of little commercial value. Moreover, the wood is very soft, and they are therefore readily broken down by winds, and are thus, more than any other kind of tree, responsible for the great number of fallen trees characteristic of the region.

White birch (*Betula papyrifera*), not often over twelve inches in diameter, is sometimes found in the drier parts of the spruce forest. As has been said, the soil in such localities is often of a lighter nature than elsewhere. White spruce (*Picea alba*), too, often grows in these areas.

(2) RIVER BANK

In the region covered by this report there are three large rivers, the Mattagami, the Frederick House, and the Abitibi. Besides these rivers there are numerous tributary streams, and along either side of all, there is a strip of country varying

in width from a few chains to two miles, which differs very much from the spruce forest. It has been called the River Bank type. A similar area around small inland lakes in also included in this type.

The soil is, as a rule, a clay loam or a loam with a good amount of humus, and, as the luxuriant natural vegetation shows, as well as the chemical and physical analyses, is admirably adapted to the purposes of the agriculturist.

Typical river bank scene. Mouth of Black river.

The most apparent difference, however, between the black spruce forest and the river bank types, is in the forest growth. The predominant tree in the latter is the aspen poplar (*Populus tremuloides*), which sometimes attains a diameter of thirty inches, averaging about fifteen. Many of the very large trees are rotten in the center, having attained their maximum size and begun to decay. The aspen has been very useful to the settlers of Manitoba and the North-west Territories for building purposes, and is still much used there as firewood. The aspen of the Clay Belt, however, is a very much larger tree than that of the West.

The next most common tree is the balsam, which averages about eight inches in diameter. As stated above it is of little value.

The white spruce, the most valuable timber tree of the Clay Belt, grows along the river banks. It frequently attains a size of twenty-eight inches in diameter, averaging about sixteen. One tree, which grew on the bank of a creek in Tully township, and which was cut down by the surveyor, measured thirty-two inches across the stump. This tree had only one hundred and twent-eight annual rings, thus indicating a rapid growth when compared with that of the ordinary tree of the black spruce forest. The white spruce is also sometimes found inland growing with black spruce, white birch, and aspen.

A growth of white cedar (*Thuja occidentalis*), is usually present along the margins of the rivers. This, for the most part, is commercially valueless; but around the shores of small inland lakes there is sometimes a growth of short thick cedar, many trees even twenty inches in diameter and not more than twenty-five feet high.

Wherever the river bank is sandy or rocky the white birch grows; but it does not often attain a great size, averaging ten to twelve inches in diameter. A few jack pine (*Pinus Banksiana*) are occasionally associated with the white birch and other trees in such localities.

Young poplar knoll. Knox Township.

Growing with the aspen almost everywhere, but much less abundant, is its close relative, the balsam poplar or balm of Gilead (*Populus balsamifera*). This tree in of small plants. These have aided greatly in enriching the soil, and in this way are of more value than commonly thought.

Besides the forest trees there is on the river bank soil, a very luxuriant growth of small plants. These have aided greatly in enriching the soil, and in this way are of more value than commonly thought.

Large poplars, 22 and 24 inches in diameter.

Finally, it should be mentioned that the surface of the river bank country in many localities, is rendered very uneven by numerous short ravines, sometimes having steep banks.

(3) POPLAR KNOLL

Here and there throughout the spruce forest is a slightly elevated area resembling the river bank type, both in soil and vegetation. Like the latter these areas are well drained, and in this respect differ from the black spruce forest.

Calculated together the river bank and poplar knoll types occupy about twenty-five per cent. of the whole region.

(4) MUSKEG

The muskegs of this region vary in size from a few acres to several square miles. In the exreme condition they are treeless tracts of deep sphagnum moss, with often a marshy pond in the centre. Around such an open muskeg the vegetation shades off gradually into the spruce forest, the moss decreasing in depth as the spruce trees increase in size. Thus there are large areas around the open muskegs with a sparse growth of stunted black spruce and tamarack, two to four inches in thickness and twelve to twenty feet in height These muskeg trees, although so small, are the oldest trees in the country, one spruce only three and a half inches in diameter being one hundred and ninety years old.

The sphagnum swamps are usually a considerable distance inland, and from the fact that small creeks were often observed to have their origins here, it would seem

that many of them can be drained, cleared, and the underlying soil used for farming purposes, as has proved true of similar areas in southern Ontario.

Typical muskeg scene.

The peat of the muskegs is sometimes over eleven feet thick, usually resting on a clay bottom. They occupy about thirteen per cent. of the whole region traversed, and in a country lacking coal will doubtless afford a valuable supply of fuel in the days to come.

(5) JACK-PINE PLAIN

As its name signifies the jack-pine plain is a level area covered with a growth of jack-pine (*Pinus Banksiana*). These trees are sometimes sixteen inches in diameter, but average about twelve. Their timber contains much resin and makes good ties. Besides jack-pine a typical desert vegetation is present,—heaths, reindeer moss, bracken fern, lycopods, sweet gale, etc. The soil is sometimes a very fine white sand, though often coarser and suitable for building purposes. As the chemical analysis shows it is of no value agriculturally.

This type of area occupies about three per cent. of the whole region traversed, and is most often found on the divides between adjacent river systems.

(6) ROCK

Occasionally small outcrops of rock, mostly of Huronian age, occur. Usually the outcrops are sparsely wooded with small black spruce. Often around an outcrop is a sandy or bouldery area on which there is a growth of white birch, white spruce, jack-pine, and sometimes a few small poplars. Rock forms less than one per cent. of the district.

SUMMARY

The region traversed, approximately one thousand square miles in area, is made up as follows:—

	Per cent.
Black spruce forest	59
River bank and poplar knoll	24.5
Muskeg	13
Jack-pine plain	3
Rock	.5
Total	100

Jack pine plain, Mattagami. Porcupine portages.

These figures have been calculated from those which are given in the description of the townships. The method of estimating the percentages of the various types of area in each township is explained in the description of the first one.

(b) Description of Townships

MURPHY TOWNSHIP TO MATTAGAMI RIVER

Four overland trips were made through this unsurveyed region, as follows:

(1) Up the western boundary of Murphy on Speight's meridian from M. VII, 50 chains to M. XII. This line was reached by ascending a creek which empties into the Mattagami near the northwest corner of Tisdale township.

(2) West from the northwest corner of Murphy to the Mattagami, eight miles and fifty chains (8 m. 50 c.)

(3) West from the western boundary of Murphy township, three miles south of the second trip, to the Mattagami river, seven miles and seventy chains (7 m. 70 c.)

(4) South, thirty degrees east, from a point on the Mattagami where it was reached on the third trip to another point on this river in that part of its course which forms the southern boundary of this area, five miles and forty chains (5 m. 40 c.)

These four trips total 26 m. 30 c., and according to my chainage notes, this distance is apportioned among the various types previously described as the following table of distances and corresponding percentages shows. The last column gives in inches the average diameter of the trees.

Type.	Mileage.	Per cent.	Trees.
Black spruce forest	18 m. 5 c.	68	7
River bank and poplar knoll	3 m. 55 c.	14	10-12
Muskeg	4 m. 50 c.	18	....
Total	26 m. 30 c.	100	....

These percentages approximately represent the proportions of the various types of country present in the region under consideration. Thus it may be said that sixty-eight per cent. of the region is black spruce forest; fourteen per cent. is river bank and poplar knoll; and eighteen per cent is muskeg. (In the descriptions of the remaining townships the percentages will be given without reference to the distances from which the percentages were calculated. It is sufficient to state that this distance averaged twenty miles and fifty-eight chains per township).

Included in the sixty-eight per cent. of black spruce forest is a considerable amount of tamarack swamp. If calculated alone it would form about four per cent. of the area. This is more than is usually present.

The strip of river bank country along the western boundary of this area is about thirty chains wide, and has a descent to the river of sixty feet in ten chains. It is well wooded with the usual river bank trees—poplar, spruce, balm of Gilead, birch, balsam and some fair cedar. The banks of the Mattagami along the part of its course which forms the southern boundary of this region are very similar.

WARK TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	56	6-7
Poplar knoll	14	10
Muskeg	30	....

On the southern boundary of Wark in the first mile from the western end, there is a deposit of gravel. This, in an almost uniformly clay country will be valuable. A small outcrop of rock also occurs on this boundary.

GOWAN TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	53	5
Poplar knoll	18	10
Muskeg	29	....

One of the largest muskegs seen during the summer occurs in this township. It extends from the northern boundary at a point two miles from its eastern extremity for three miles in a southerly direction, and at least two miles from east to west. Indeed, it is probably a continuation of the muskeg that was crossed in Wark at this latitude.

The Porcupine river touches upon the southern boundary of Gowan, and a western branch of this river drains a portion of the township. The banks of these streams are ten to twenty-five feet high, and are of the usual type, being well wooded with poplar, some twenty inches in diameter, averaging, however, thirteen; white spruce, many sixteen to twenty-two inches; balsam, black spruce and balsam poplar. This river flows through Hoyle, the township south of Gowan, and throughout its whole course its banks are of this nature.

Wark and Gowan are very flat townships, and are poorly drained. This fact is indicated in the table by the large per cent. of muskeg, and the small amount of poplar knoll.

PROSSER TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	74	7 (brulé excepted).
Poplar knoll	9	12
Muskeg	16	....
Rock	1	....

A brulé wooded with small spruce, tamarack, willow, balsam and birch about thirty years old, extends along the northern boundary of Prosser township. It begins 1 m. 33 c. from the eastern boundary and reaches a point 1 m. 65 c. from the western. It also stretches south 50 c. into Prosser, and about 2 m. into the township north of Prosser. Flowing in a northwesterly direction through this brulé is a stream twenty-five feet wide, which crosses the northern boundary 2 m. 12 c. from its eastern end. This creek courses in a beautiful valley thirty feet deep and eight or ten chains wide, with excellent clay loam soil.

Casual mention was made in the general description of the many fallen trees in the Clay Belt. An area extending two miles south from the northern boundary at a point two miles from its western end illustrates very well the extreme of this condition. In this area there are very few standing trees. In one locality there is a stretch of twenty chains without any. Spruce, poplar and tamarack lay piled over one another, so that for chains at a time one can walk over tree trunks without touching the ground at all. This was the most marked "windfall area" seen in the whole region traversed. The soil was clay loam with boulders in places.

At a point within the township about 5 m. south and 3½ m. west of its northern and eastern boundaries, respectively, there is a hill of rock about one hundred and twenty feet high. From the top of this hill a vast extent of conical tree-tops (black spruce) of a dark green color is seen. Many brown stretches of dead tamarack occur, especially numerous to the westward. The lighter green of the poplar knolls, which appear here and there as islands in a sea of black spruce, adds to the beauty of the scene. The poplar knolls form, apparently about one-tenth of the whole field of vision. The whole surrounding country is very flat, and the horizon consequently an almost unbroken straight line. Here and there in the far-distant south and west, however, it is interrupted by an elevation apparently similar to the one ascended. To the north the surface rises gradually, the horizon appearing not more than three miles away.

TULLY TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	71	6
Poplar knoll	10	11
Muskeg	19	....

Flowing in a northerly and westerly direction are some small creeks, the largest thirty feet wide, the banks of which are low and wooded mostly with spruce. In many places a luxuriant growth of beaver hay, a chain or two wide, borders the streams. The soil in these localities is a very rich clay loam.

This township resembles the preceding ones in its general flat nature.

TOWNSHIP NORTH OF PROSSER

Type.	Per cent.	Trees.
Black spruce forest	85	8 (brulé excepted.)
Muskeg	15	....

The brulé which in the description of Prosser was said to occur on its northern boundary, extends about two miles north into this township, and then sends an arm one-half mile wide in a north-westerly direction across the western boundary. It is thus of considerable size, occupying about one-fifth or one-sixth of the whole township.

A creek, thirty-five feet wide, flows northwest across the eastern boundary 3 m. 45 c. from its southern extremity. Its banks, of clay loam, are fifteen feet high, and wooded with fair-sized black and white spruce. A creek of about the same size, flowing north, was crossed on the north boundary 1 m. 22 c. from its western extremity. At this point it has low swampy banks, bordered with alder.

TOWNSHIP NORTH OF TULLY

Type.	Per cent.	Trees.
Black spruce forest	70	8
Poplar knoll	14	13
Muskeg	16	....

The surface of this township is inclined to be rolling. In the northern part are several small lakes, with banks twenty or thirty feet high, well timbered with poplar averaging sixteen inches in diameter; white spruce, fifteen inches; birch, ten inches; and some black spruce. Some areas, especially in this part of the township, are admirably adapted to suit the needs of the farmer.

REGION NORTHWEST OF PROSSER

Type.	Per cent.	Trees.
Black spruce forest	93	7
Muskeg	7	....

This unsurveyed area was traversed as follows: (1) West from the northwest corner of Prosser, 3 m.; north, 1 m.; east, 3 m. (2) West from the west boundary of the township north of Prosser, 3 m.; north of the termination of the first trip, 3 m.;

north, 2 m.; east, 3 m. Thus this region lies west of the western boundary of the township north of Prosser, and is three miles wide.

As the table shows, this area is very largely a spruce forest, but among the black spruce there are a good many dead tamarack. In fact, in the southern part there are some stretches of tamarack swamp. Doubtless the surface is better drained farther west nearer the Mattagami river.

SECOND TOWNSHIP NORTH OF PROSSER

Type.	Per cent.	Trees.
Black spruce forest	78	7 (brulé excepted)
Poplar knoll	5	11
Muskeg	15	....
Rock	2	....

Occupying a very large proportion of the western half of this township, is an area of brulé about thirty years old. At the present time this area is a small spruce and tamarack thicket, growing on a clay subsoil, which is overlaid by one to three feet of black mould. This brulé crosses the western boundary, beginnnig 20 c. from its southern end, and continuing north for 1 m. 70 c. It also extends across the southern boundary beginning 1 m. 20 c. from its western end and continuing east for 40 c.

There is a gradually rising granite hill, eighty feet high, at a point within the township 3 m. 40 c. north and 2 m. west. The sides of this outcrop which extends about 30 c. from north to south, are wooded with black and white spruce, averaging fifteen inches in diameter; white birch, fourteen inches; and cedar, twelve inches. Particularly interesting as far as this report on the timber is concerned is the fact that on this hill are seven white pine (*Pinus strobus*), the largest twenty-two inches in diameter. This is one of the very few clumps of white pine seen during the whole summer. The thin covering of soil about this outcrop consists in some places of a white powdery clay, and in others of a light white sand.

The creeks of this township are about the same size as those in the one to the south, and indeed are probably continuations of them. They will be valuable agriculturally.

SECOND TOWNSHIP NORTH OF TULLY

Type.	Per cent.	Trees.
Black spruce forest	71	7
Poplar knoll	20	14
Muskeg	9	....

The black spruce forest of this township is more broken than usual by areas of dead tamarack. Fallen trees, too, are rather exceptionally numerous.

Near the middle of the township there is an area of dry rolling land, mostly clay loam, but in some places sandy, which is wooded with many large white birch, averaging fifteen inches; white spruce, fifteen inches; some poplar and balm, fourteen inches; and a thick undergrowth of mountain maple and hazel. This area was entered at a point 2 m. from the western boundary, and 4 m. 19 c. from the southern and continued north for 41c. It stretches a mile to the east, and in this part there are four small lakes, with banks in some places about fifty feet high, wooded with timber like that just described. Around these lakes are some good cedar, the best seen during the whole summer, many trees being sixteen inches in diameter.

LITTLE TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	56	8
Poplar knoll and river bank	15	14
Muskeg	16	....
Jack pine area	13	5-6

The Frederick House river flows almost diagonally through this township, from southeast to northwest. In this part of its course it is about two chains wide, and has a sluggish current, unbroken by any rapids. For the first mile it has low swampy banks wooded with ten-inch black spruce, but for the rest of its course in this township its banks are from thirty to forty feet high, of good clay loam, and well wooded with poplar and balm of Gilead, sometimes twenty inches in diameter, but averaging sixteen, and white spruce, sixteen inches. This timber and soil extend inland about twenty chains.

The southern boundary of Little extends for 1 m. 15 c. from its eastern end through spruce woods. The trees average eight inches in diameter, and grow on a clay subsoil, overlying which is a foot of black mould. The next 47 c. extend over a small muskeg, and the rest of the southern boundary through a jack-pine area, in which is an occasional small muskeg with a sand bottom. This area was burned over about fifteen years ago, and is now wooded with small trees, five or six inches in diameter. As usual in jack-pine areas the soil is a very light sand, and of no value agriculturally. Toward the western end of this boundary there are several sandy hills covered with young white birch and jack-pine. The jack-pine region extends in a northwesterly direction from the point where it begins on the southern boundary, *i. e.* 1 m. 62 c. from the eastern side of the township, for a distance of about three miles. It is, however, broken by small areas of muskeg (probably with sand bottoms), tamarack swamp, and one small rock outcrop. Thus the southwest corner of Little, an area probably about one-fifth to one-quarter of the township, is of no value for farming purposes.

MANN TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	66	7 (brulé excepted.)
River bank and poplar knoll	26	12 (brulé excepted.)
Muskeg	8	....

The Frederick House river runs north through Mann township a short distance from its western boundary. Its banks are here about thirty feet high and for the southern two miles well wooded with the two poplars, spruce and balsam. This timber extends about thirty chains inland. For the northern four miles, however, its banks are covered with small poplar, spruce, balsam and birch, about thirty years old.

The first falls on the Frederick House occurs just within the southern boundary of Mann. Here there is a drop of forty-six feet, which would afford valuable water power.

A large proportion of this township was burned over about thirty years ago, and is now wooded with spruce and tamarack, five to six inches in diameter, and poplar, six to eight inches. The brulé extends to the river banks, as mentioned above, along the northern four miles of its course through this township. It reaches a short distance across the northern boundary beginning 2 m. 17 c. from its western extremity,

and continuing east for 3 m. 43 c. It appears also on the southern boundary, beginning 1 m. 30 c. east of the river and extending east to the edge of a large muskeg. This muskeg occupies the southeastern corner of the township, and in extent is about one mile from east to west, and a mile and a half from north to south. It is over seven feet deep and would thus afford a considerable supply of peat.

Falls on Frederick House river, Mann Township. One of upper cascades.

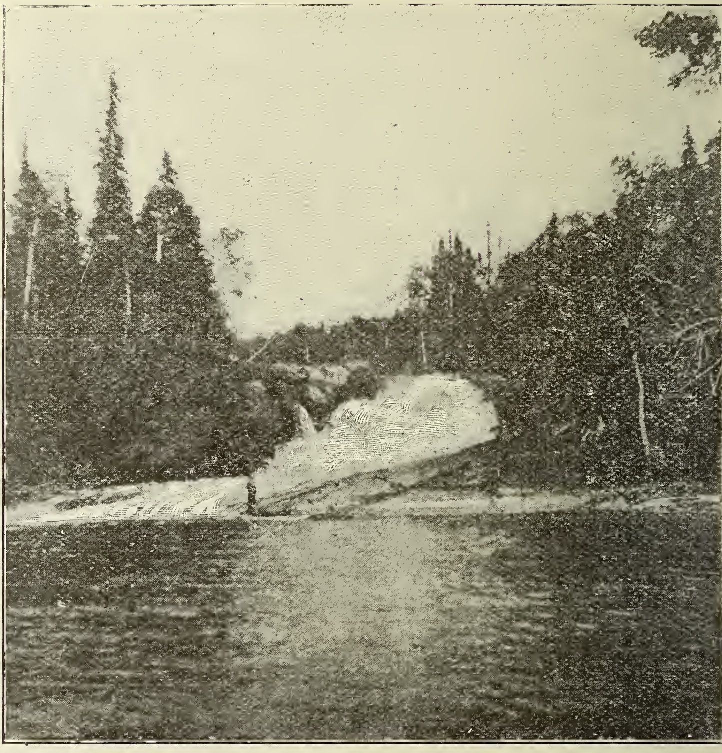
The labor of clearing the land in this township will be reduced to a minimum on account of the large amount of brulé. The soil is the usual clay loam, and the drainage is good.

TOWNSHIP NORTH OF MANN

Type.	Per cent.	Trees.
Black spruce forest	60	8
River bank and poplar knoll	27	14
Muskeg	13	....

The Frederick House river continues its northerly course through this township, and, as in Mann, flows quite near the western boundary. Its banks are about thirty-five feet high and are wooded with a strip, ten to twenty chains wide, of spruce, averaging fifteen inches in diameter; birch, ten inches; poplar, fourteen inches; balsam and balm of Gilead, eleven inches. Thus there are more birch here than usual.

The soil is sandy in many places, and in one locality, ten chains north of the southern boundary, where the bank is quite steep, the soil on the summit is a sand loam, while half way down the slope it is clay. In many other localities throughout the whole of the region traversed, where sand was found on the surface, the under-



Falls on Frederick House river, Mann Township. Lower western cascade.

lying soil, often only a few inches below, was found to be clay. Thus, while sometimes heavy poplar were apparently growing on sandy soil, closer examination usually revealed the fact that the sand was a surface-covering only a few inches in thickness. This is the case, for example, on Couchiching Falls portage.

A creek, one chain wide at its mouth, empties into the Frederick House forty chains south of the northern boundary of the township. This creek was ascended in a southeast direction for two miles and a half, where farther passage was blocked by driftwood, the creek now being narrowed to thirty feet. It has clay loam banks, ten to twenty feet high, wooded with spruce, balsam, poplar and some birch.

The brulé of Mann township which has been said to extend across the northern boundary into this one, did not appear on an east and west exploration line two miles north of the southern boundary. Thus the brulé cannot extend far into this township.

The fact that there is an unusually large number of fallen trees in this township should be mentioned. Their presence will considerably increase the difficulty of clearing the land.

SECOND TOWNSHIP NORTH OF MANN

Type.	Per cent.	Trees.
Black spruce forest	55	8 (brule excepted.)
Poplar knoll	34	13
Muskeg	11	....

A large proportion of this township was burned over about forty-five years ago. Hence much of the fifty-five per cent. of spruce forest is a small spruce and tamarack thicket, but the remainder is of trees averaging eight inches in diameter. The poplar knolls, too, are largely brulé, but the trees have grown remarkably quickly, and average thirteen inches in diameter. One, which measured fifteen inches, had only forty-three rings of growth. It was a perfectly solid tree, forty feet high. The soil is a rich clay loam.

This township seems to be fairly well drained, having a rolling surface, and some streams of moderate size. The Frederick House river flows northwest across its southwestern corner, crossing the western boundary one mile from the corner, *i. e.*, at m. 157 on Niven's line.

McCART TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	56	11
Poplar knoll and river bank	10	11
Muskeg	12	....
Jack pine area	20	10
Rock	2	....

The surface of McCart township is inclined to be rolling in nature. The streams are of fair size, one in the middle of the township, being fifty feet wide. Along these streams are many large white spruce, some even twenty-nine inches, but averaging seventeen, and some birch, but very few poplar.

The middle two miles of the eastern boundary run through jack-pine country, which has within its limits several small lakes. These are bordered by sandy and gravelly banks, thirty to forty feet high, wooded with jack-pine and white birch. This area extends in a southwesterly direction until it reaches the southern boundary along the eastern end of which it extends for two miles. The trees of this area will make good railway ties.

Within the township about one mile north and three miles east is a ravine of glacial origin, with banks about sixty feet high, composed of coarse sand, gravel and boulders. The value of such a deposit in an almost wholly clay country is self-evident. In this locality the timber is very heavy, white spruce, twenty inches in diameter, and white birch, sixteen inches, being very numerous. These birch were the largest seen during the whole summer. In this township the white birch is quite often found growing in the black spruce forest. A few large yellow birch (*Betula lutea*) were seen along the southern boundary, but this tree is of rare occurrence in the region traversed.

While the more valuable timber trees, white spruce and white birch, are more numerous and of a larger size than usual, the opposite is true of the poplar. As this fact would indicate, the soil is lighter than is usual, there being a considerable amount of sand loam in McCart, besides the exceedingly light soil of the jack-pine area in the eastern part of the township.

NEWMARKET TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	58	7
Poplar knoll	16	10
Muskeg	26	....

The black spruce forest of this township is considerably broken by areas of tamarack swamp, in which there is now a very dense growth of heavy alder.

The central part of the township has a rolling surface, and here white spruce and poplar are scattered through the black spruce forest. This part of the township, with its beautiful valleys will make exceptionally good farming country.

CALVERT TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	33	11
Poplar knoll and river bank	43	15
Muskeg	5	....
Jack-pine area	17	12
Rock	2	....

The Abitibi river flows north through Teefy township, about one-half mile from the eastern boundary of Calvert. Near the northwest corner of Teefy it takes a turn to the northwest and flows across the corner of this township. The river bank type of soil and timber extend inland in this part of the course of the Abitibi about three-

Black spruce forest, looking north from top of rocky hill. Calvert Township.

quarters of a mile. Consequently, the eastern part of Calvert is well drained, has numerous ravines, some forty to fifty feet deep, and is heavily timbered. Deep ravines are characteristic of townships on the Abitibi river, and the banks of these in nearly every case are heavily wooded with poplar, white spruce, balsam, black spruce and balm of Gilead. Jack-pine and white birch occasionally occur in parts having a light

soil. Thus in the poplar areas in the eastern part of this township there are many large white spruce eighteen inches in diameter, but averaging about sixteen, besides the poplar, which average eighteen inches.

The jack-pine plain, which in the description of McCart township was said to stretch along the middle two miles of its eastern boundary extends into this township in a northeast direction. Along the line between concessions five and six it extends for 2 m. 55 c. The trees average twelve inches. Along this line one mile and three-quarters from the western boundary the jack-pine plain is broken by a rocky hill about one hundred feet high. Owing to the covering of black spruce and jack-pine on this hill a good view of the surrounding country could not be obtained. What could be seen to the north appeared to be nearly all black spruce forest.

AURORA TOWNSHIP

Type.	Per cent.	Trees
Black spruce forest	73	9
Poplar knoll and river bank	17	13
Muskeg	10	....

The Abitibi river flows north through the middle of this township. Above the Buck Deer rapids the banks are quite low, and are wooded with black and white spruce, averaging fifteen inches, birch and balsam. The soil here is sandy and

Abitibi river bank just above Buck Deer Rapid, Aurora Township.

poor in humus and other constituents of value, as the chemical analysis shows—an unusual condition on a river bank. From the Buck Deer rapids to the northern

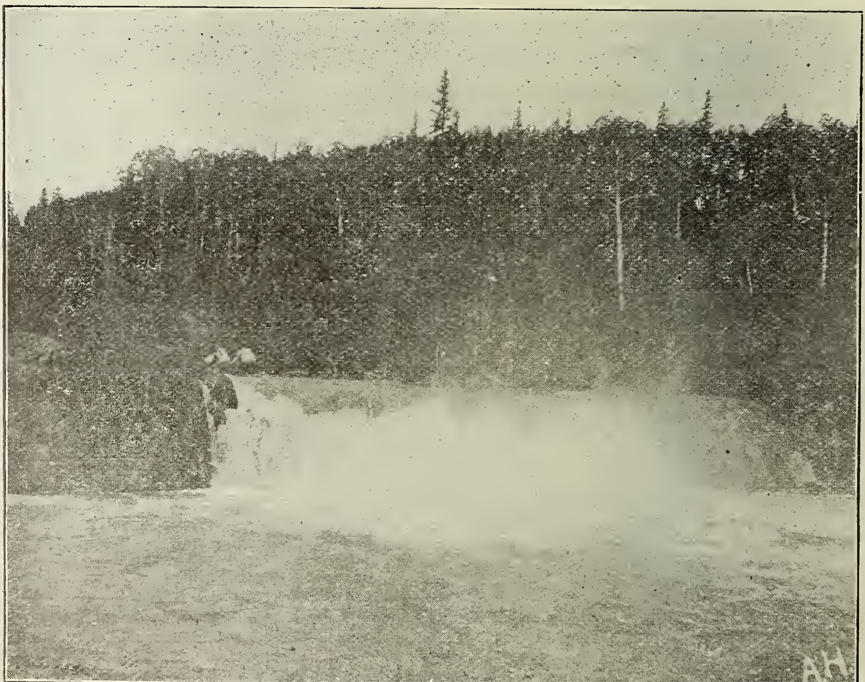
boundary the river banks are much higher, and are wooded in the ordinary way, *i. e.*, with good poplar and large white spruce predominating. Some fair sized cedar, many trees fifteen inches in diameter, also occur.

Inland from the river the township is largely of the black spruce forest type. The trees, though of a fair size, averaging nine inches, are rather scattered, as there are a great many "windfalls" in this township. The soil is for the most part the usual clay loam.

TEEFY TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	32	11
River bank and poplar knoll	62	18
Muskeg	1	....
Jack pine area	5	....

The Abitibi river flows through Teefy township in a course shaped like a horseshoe, with the concavity directed northward. Toward the eastern side of the township the banks are rather steep, about seventy feet high, and wooded with poplar, some twenty-nine inches in diameter, but averaging eighteen; black and white spruce,



Iroquois Falls, western division, Teefy Township.

fifteen inches; balm of Gilead, sixteen inches; balsam and occasional birch and jack-pine. Along the western part of its course the river has lower and more gradually rising banks, beautiful slopes with timber and soil as in the other part. In this western part Iroquois falls, fifteen feet high occur. These falls will be a source of

Iroquois Falls, western and central divisions, Teefy Township.

valuable water power. The river banks, in both the eastern and the western parts of its course, are broken by numerous ravines, the depth varying with the height of the banks. Many of them have steep sides.

Abitibi river bank near north-east corner of Teefy Township.

A very rich clay loam soil is common to the sixty-two per cent. of the township covered with river bank and poplar knoll timber. The river bank timber extends inland from one to two miles, and farther inland are many poplar knolls with timber and soil like that of the river bank.

The jack-pine occur along the eastern boundary beginning ten chains south of the river, and extending south for 1 m. 12 c. Some white birch, black and white spruce and balsam are associated with the jack-pine in this locality. Three small lakes occur along this boundary.

EDWARDS TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	64	9 (brulé excepted)
Poplar knoll	22	13
Muskeg	13	....
Rock	1	....

An area of brulé twenty to thirty years old occupies the northeast quarter of this township. Throughout the brulé there are occasional small islands of the original forest. Elsewhere it is a small spruce and tamarack thicket, with few poplar and birch.

On the northern boundary 2 m. 20 c. from its eastern end there is a hill of rock about sixty feet high. From the top of this hill the country to the north appears to be almost wholly black spruce forest, while to the south there is a considerable proportion of poplar knoll, indicating better drainage in that direction.

The muskeg, it would seem, is for the most part near the center of the township.

RICKARD TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	38	10
River bank and poplar knoll	53	16
Muskeg	4	....
Jack-pine area	5	....

The Abitibi river pursues a westerly course near the northern boundary of Rickard township. Its banks are lower and more gradually sloping than in the eastern part of Teefy, the adjoining township to the west. Ravines, similar to those in Teefy, occur along the river banks, but are not so numerous nor so deep. The river bank timber and also that of the inland part of the township resembles the timber of Teefy, but is not quite so heavy.

The jack-pine area occurs along the western boundary, and has been referred to in the description of Teefy.

WESLEY TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	42	8 (brulé excepted)
Poplar knoll and river bank	48	15 (brulé excepted)
Muskeg	10	....

Flowing in a southwesterly direction, almost diagonally across Wesley township, is the Misto-ogo river, a tributary of the Abitibi. This river is about one chain wide in the centre of the township. Some of its branches flow through beautiful valleys.

The brulé, which has been said to occupy the northeastern part of Edwards, is also present in this township, and here, too, is of considerable size. It was seen in the following localities: (1) On the western boundary, from a point 40 c. from the northwest corner of the township, extending south 2 m. 10 c. (2) On the eastern boundary, from a point 1 m. 17 c. from the southeastern corner of the township,

extending south 1 m. 73 c. It thus reaches into Rickard and Knox for a short distance. (3) On a north and south line, 2 m. from the eastern boundary, beginning 3 m. 10 c. from the northern boundary, and extending south for 1 m. 59 c.

Thus there appears tô be a strip of brulé about two miles wide extending across the township from southeast to northwest. Most of this is of the poplar knoll type.

KNOX TOWNSHIP

Type.	Per cent.	Trees.
Black spruce forest	26	8
Poplar knoll and river bank	70	15
Rock	4	....

The Abitibi river flows westerly through Knox, slightly north of the middle of the township. Its banks are similar to those in Rickard, both in soil and timber.

Along the southern half of the eastern boundary and the eastern half of the southern boundary are several low rocky ridges wooded with black spruce and white birch. In the intervening valleys the soil is clay loam on which grows poplar, spruce, balsam and balm. Occasionally sandy soil occurs, and here white birch of a fair size is found growing with the black spruce.

At a point 2 m. 48 c. west and 58 c. to 75 c. north is a rocky hill, one hundred and fifty feet high. The nature of the country as indicated by the view from this hill contrasts very favorably with that of the area about the similar hill in Prosser. In the latter case most of the country visible was a black spruce forest with stretches of dead tamarack and occasional poplar knolls. In this case, on the other hand, the surrounding country is almost wholly wooded with poplar, and there is only here and there a small area of black spruce. This township thus, as indicated by its timber, is well drained, and although the large number of fallen trees will render clearing difficult, it will be especially valuable from the agricultural standpoint.

MOODY TOWNSHIP

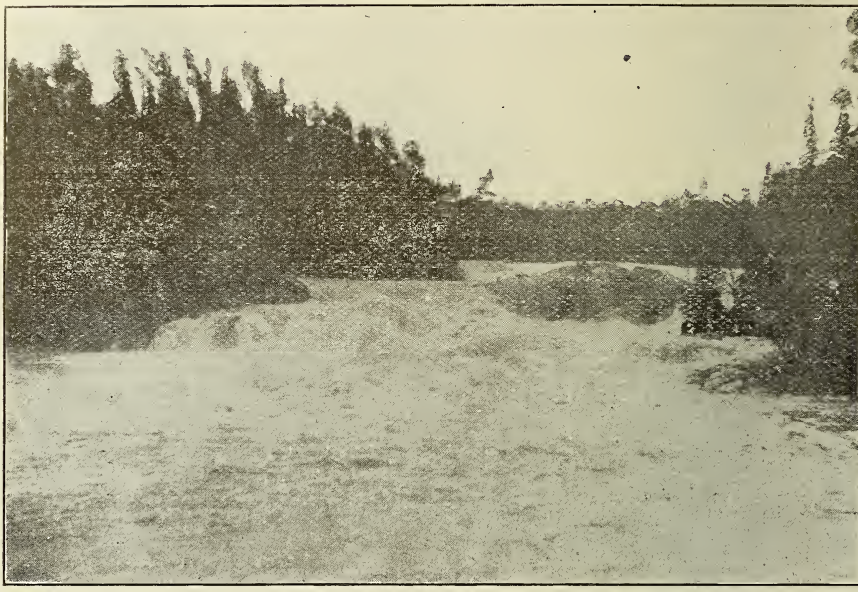
Type.	Per cent.	Trees.
Black spruce forest	49	7
Poplar knoll	21	14
Muskeg	20	....
Jack-pine area	10	11

As these percentages indicate, Moody township is poorly drained. A large muskeg extends south from the middle point of the township for 2 m. 27 c. In the centre it is at least a mile wide, and is over seven feet deep.

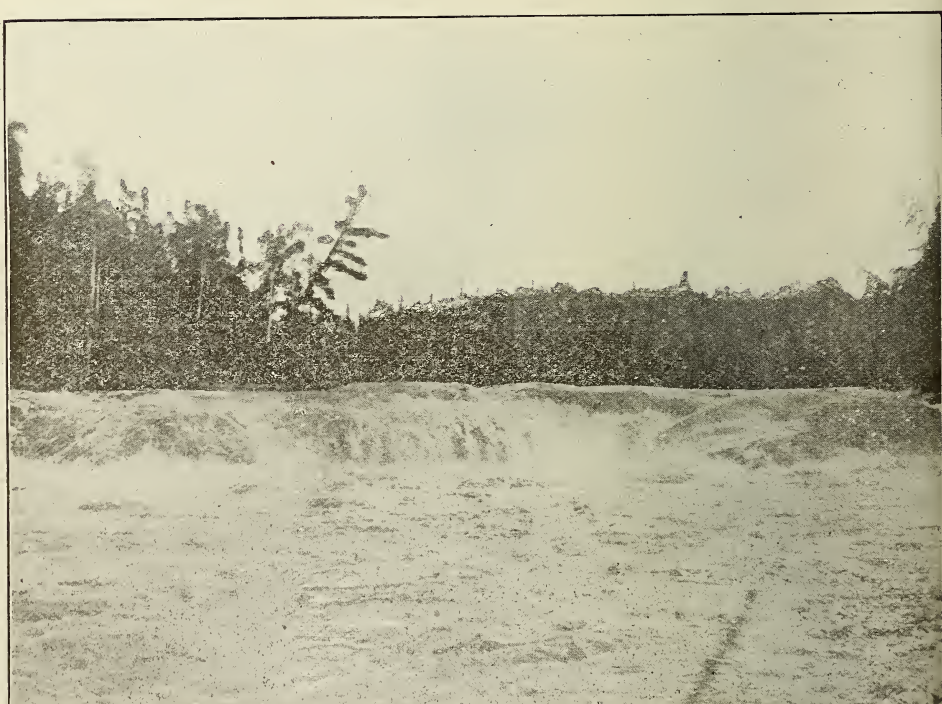
Along the eastern boundary on the second and third miles from its southern end, are several narrow jack-pine ridges, the trees averaging from ten to twelve inches in diameter.

TOWNSHIP EAST OF KNOX

Type.	Per cent.	Trees.
Black spruce forest	42	8
River bank and poplar knoll	53	15
Muskeg	2	....
Jack-pine area	2	....
Rock	1	....



Couchiching Falls, Abitibi river.



Couchiching Falls, Abitibi river, upper drop.

The Abitibi flows west about three miles north of the south boundary of this township. Its banks are about thirty-five feet high, and are of the ordinary type, clay loam wooded with poplar and spruce chiefly. Couchiching Falls, thirty-five feet high, occur about one mile and a half from the western boundary and would afford valuable water power.

Flowing into the Abitibi from the south about three miles from the western boundary is a beautiful stream of clear water, the Dokis creek, one chain wide at its mouth. Its banks are from ten to fifteen feet high, are of clay loam and well wooded.

Some areas of sand loam occur in this township, *e. g.*, along the southern boundary. On this boundary, too, 4 m. 7 c. from the western end, there is a spring of sulphur water which deserves mention.

Only the western and northern boundaries of this township have been run.

TOWNSHIP EAST OF MOODY

Type.	Per cent.	Trees.
Black spruce forest	57	7
Poplar knoll	18	14
Muskeg	12	....
Jack-pine area	13	....

The immediate shore of lake Abitibi, which adjoins the eastern side of this area, is for the most part very rocky though in some places sandy, and in others swampy. The neighboring bank is from thirty to fifty feet high, and is wooded with spruce, birch, jack-pine, poplar and balsam, growing mostly on a sandy soil.

The northern part of this area, that which is drained by the Dokis river, is from the agricultural standpoint, the most valuable.

Only the western and northern boundaries of this township have been run.

THIRD TOWNSHIP NORTH OF TULLY

The number of miles travelled in this township (and also in the next one), is so much smaller than usual (the average being 20 m. 58 c.), that it will not justify the drawing up of a percentage table.

The Frederick House river flows northwest across the eastern boundary one mile from its southern extremity, and continuing its northwesterly course crosses the north boundary at its middle. For the northern two miles its banks are about thirty-five feet high, of a clay loam soil, and are wooded with large poplar, spruce, balsam and some balm, and birch. At the northern boundary this timber extends inland fourteen chains on the west side of the river. For the rest of its course in this township the banks are lower, are of a sandy soil, and are wooded with spruce, birch, balsam and few poplar.

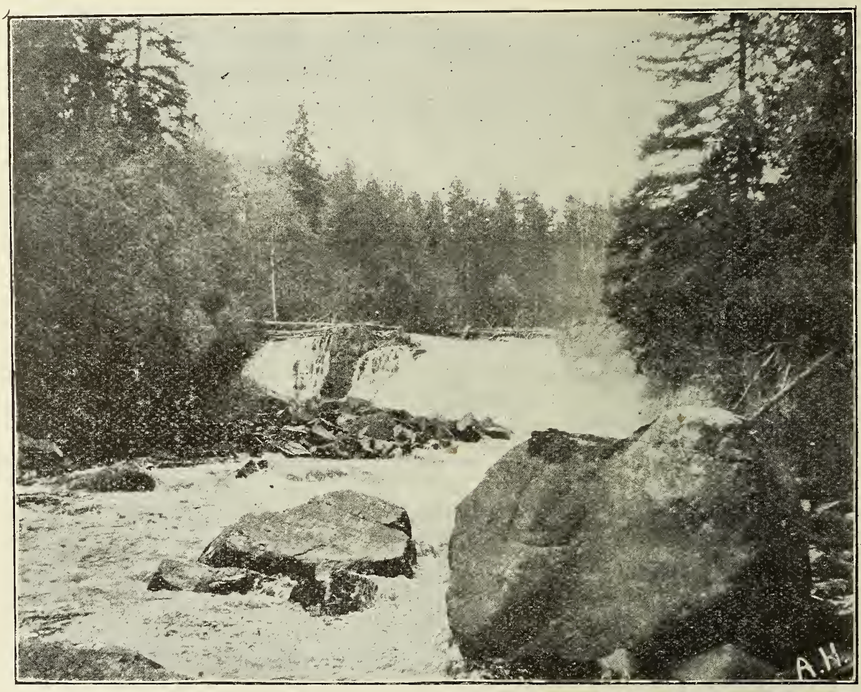
Several lakes in this township have steep banks, forty feet high, wooded with large spruce, poplar and birch. These lakes would appear to form part of a chain of small lakes about one mile west of the river.

Inland the township is largely of the black spruce forest type, with trees averaging seven inches in diameter.

THIRD TOWNSHIP NORTH OF PROSSER

Flowing north through this township and crossing its northern boundary 1 m. 24 c. from its eastern extremity is a river two chains wide, with banks about twenty-five feet high, wooded as usual. The trees here however are young ones, one poplar seventeen inches in diameter having only forty annual rings—a remarkably quick

growth. The brulé, of which these large poplar trees form a part, extends along nearly all of the northern boundary, and is mostly a small spruce and tamarack thicket. One of the finest poplar knolls seen during the summer, however, is included in this brulé, and occupies the northwestern corner of the township. The trees average twelve inches in diameter, are about forty years old, and there is scarcely a fallen tree



Falls on Montreal River at Great Northern Bend.

in the whole area. Only small stretches of this brulé were seen on an east and west line three miles south of the northern boundary. This line extended for the most part through wet spruce woods, the trees averaging six to seven inches in diameter. Here and there however were small areas of muskeg.

II. CLIMATE

Temperature

An accurate record of the temperature was kept during the four months in the Clay Belt. The minimum temperatures were registered by a minimum thermometer, and the readings were made about seven a. m. The temperatures noted between one and two p. m. are approximately the maximum. In addition to the minimum and maximum temperatures a reading was made in the evening about half-past eight o'clock.

These temperatures are presented in the following table, together with some notes on the amount of rainfall and sunshine, and the relative velocity and direction of the winds.

JUNE

Date.	Minimum.	Maximum	8.30 p.m.	Rain, sunshine, winds.
3	37	....	63	Clear.
4	43	....	....	Cloudy, showers in morning and evening.
5	47.5	66	....	Cloudy.
6	52	67	....	Cloudy, showers at intervals.
7	48	....	57	Cloudy, rain all morning.
8	30	....	68	Clear, strong N. W. wind.
9	42	76	62	Clear.
10	38	82	70	Clear.
11	39	80	....	Clear.
12	42	86	68	Cloudy in evening.
13	49	76	68	Mostly clear. rain at night.
14	45	66	58	Rain until 11 a.m.. Showery after. Strong N. W. wind.
15	42	58	52	Cloudy. N. W. wind.
16	37	76	64	Clear. N. W. wind.
17	36.5	61.5	59	Cloudy, shower from 3 to 4 p.m., with thunder in distant west. S. E. breeze.
18	42.5	60	50	Clear. S. W. breeze.
19	33.5	84	63	Clear.
20	51	82	70.5	Clear. N. W. breeze.
21	52	62	46	Cloudy. Strong N. E. Wind.
22	28	64	52	Clear.
23	37	75	70	Clear.
24	57	75	74	Cloudy, showers after 4 p.m. Strong S. W. wind.
25	56	77	70	Cloudy.
26	56	62	49	Passing clouds. Very strong S. W. wind Dead tamarack blowing down about camp.
27	39	74	61.5	Clear. Strong N. W. wind.
28	40	73	64	Clear. Strong S. W. wind.
29	40	71	60	Showers after noon. N. W. wind.
30	50	74	56	Cloudy. Showers in a.m. Strong northerly wind.

JULY

Date.	Minimum.	Maximum.	8.30 p.m.	Rain, sunshine, winds.
1	39	62	53	Clear. N. W. wind.
2	39	57	60	Clear. N. W. breeze.
3	38	75	59	Clear. Strong S. W. wind.
4	48	60	54	Cloudy. S. W. breeze. Shower at night.
5	43	64	52	Cloudy at intervals.
6	40	68	44	Clear.
7	33	84	64	Clear.
8	42	81	63	Clear.
9	58	66	64	Rain until 2 p.m., cloudy afternoon.
10	58	78	58	Clear. N. W. breeze.
11	48	70	68	Clear.
12	52	52	45	Cloudy. Showers after noon. S. E. breeze.
13	36	77	63	Cloudy. Shower about 2 p.m.
14	39	78	69	Cloudy after noon.
15	56	70	67	Showery.
16	47.5	67.5	62.5	Cloudy in a.m. N. W. breeze.
17	50	87	62	Thunder storm in early morning. Clear after 7 a.m.
18	42	84	78	Clear. W. breeze.
19	65	80	64	Clear.
20	42	65	56	Clear. N. W. breeze.
21	33.5	68	51	Mostly clear. Showery in p.m. N.W. breeze.
22	30	61	48	Clear.
23	26	76	56	Clear.
24	33	75	62	Clear.
25	50	77	62	Clear.
26	55	80	58	Clear.
27	56	72	65	Showery.
28	46	60	52	Cloudy. W. breeze.
29	37	74	62	Clear. S. W. breeze.
30	40	60	60	Cloudy, rain all morning.
31	52	74	56	Clear. Strong S. W. wind.

AUGUST

Date.	Minimum.	Maximum.	8.30 p.m.	Rain, sunshine, winds.
1	43.5	58	50	Mostly clear.
2	35	74	60	Cloudy after noon and two showers.
3	43	72	59	Clear.
4	48	76	68	Cloudy after noon.
5	57	66	60	Rain in morning. Strong S.W. wind.
6	50	54	50	Rain all day. Strong S.W. wind.
7	44	58	45	Showery.
8	36	70	60	Mostly clear.
9	36	68	54	Clear.
10	50	56	50	Showery.
11	39	69	55	Clear.
12	46	66	59	Mostly clear. Rain at night.
13	52	70	52	Cloudy.
14	46	60	42	Cloudy in p.m.
15	31	59	50	Cloudy towards evening.
16	40	56	52	Clear in p.m. Strong W. wind.
17	39	56	46	Showery.
18	33	65	57	Showery after 3.30 p.m.
19	39	65	60	Clear.
20	48	72	62	Mostly clear.
21	46	72	68	Cloudy. Rain at night.
22	54	59	46	Cloudy in a.m. S.W. wind.
23	36	66	67	Clear. Strong S.W. wind.
24	58	67	62	Cloudy. Rain at night.
25	57	67	41	Showery. Very strong W. wind.
26	41.5	66	53	Clear.
27	45	77	60	Mostly clear. Thunder shower about 4 p.m. W. breeze.
28	53	66	48	Clear. Showery in evening.
29	28.5	60	45	Clear. Showery in evening.
30	36	53	43	Clear.
31	27	60	52	Clear. W. breeze.

SEPTEMBER

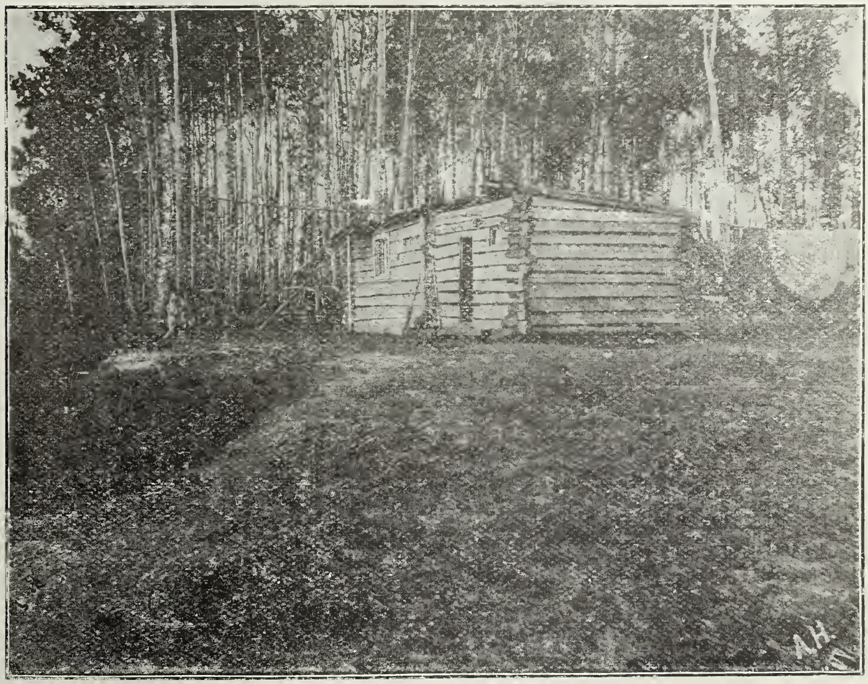
Date.	Minimum.	Maximum	8.30 p.m.	Rain, sunshine, winds.
1	43	62	50	Cloudy, drizzling in a.m.
2	39	56	43	Rain in p.m.
3	42	62	56	Rain all day. An autumn day.
4	44.5	56	46	Showery.
5	32	51	42	Clear.
6	27	62	53	Clear. N.W. breeze.
7	43	68	48	Mostly clear.
8	33	56	46	Mostly clear.
9	44	61	57	Mostly clear.
10	50	74	68	Cloudy after 2.30 p.m.
11	52	43	46	Cloudy. N.W. breeze.
12	33	50	37	Cloudy at intervals.
13	27	50.5	46	Cloudy. Rain at night.
14	41.5	52	45	Rain in a.m. N.W. wind.
15	34	56	41	Mostly clear.
16	35.5	54.5	42.5	Showery. Strong N.W. wind.
17	30.5	51.5	48.5	Rain. N.W. breeze.
18	37	46	33	Rain.
19	25.5	43	38	Cloudy.
20	31.5	38.5	34	Snow flurries. Strong N.W. wind.
21	30	41.5	37	Mostly clear. Occasional snow flurries.
22	25	54	36	Clear.
23	33	46	50	Steady rain.
24	43.5	61	45	Cloudy, drizzling after 2 p.m.
25	32	43	41	Cloudy.
26	40.5	44.5	35	Cloudy until 3 p.m.
27	29	55.5	40	Clear.
28	32	67	55	Clear. Rain at night.
29	48	62	56	Cloudy. Rain before 8 a.m. W. wind.
30	45.5	48	46	Showery after noon. Very strong N.W. wind.

The next table gives the average daily minimum and maximum temperatures for each month, and the monthly extremes of the summer of 1904, in the Clay Belt and in the vicinity of Guelph. These latter figures were kindly supplied by Professor Reynolds of the Ontario Agricultural College.

TEMPERATURE OF CLAY BELT AND GUELPH

Month	Region	Mean daily Minimum	Mean daily Maximum	Monthly Minimum	Monthly Maximum
June..........	Clay Belt	43.42	71.98	28.00 on 22nd	[illegible]6.00 on 12th
	Guelph	52.00	73.26	41.50 on 23rd	84.00 on 25th
July	Clay Belt	44.32	70.95	26.00 on 23rd	87.00 on 17th
	Guelph	54.87	77.15	42.00 on 3rd	90.25 on 18th
August........	Clay Belt	43.14	64.58	27.00 on 31st	77.00 on 27th
	Guelph	52.01	74.77	42.00 on 9th	84.00 on 13th
eptember...	Clay Belt	36.78	53.75	25.00 on 22nd	74.00 on 10th
	Guelph	48.36	67.23	30.00 on 22nd	81.5 on 2nd and 3rd

On comparing the Clay Belt temperatures with those of southern Ontario, it will be observed that there is little difference between the maximum temperatures in the two regions for the months of June and July. The minimum temperatures, however,



Indian hut and potato patch, west shore of Frederick House Lake.

differ considerably. This would be expected as many of the readings were made in wet spruce woods, in some of which, even in the late summer, ice was found only a foot or two below the surface of the moss. The minimum temperature registered at

night would be much more affected by the proximity of this ice than the maximum taken between one and two o'clock, when the heat of the sun is greatest. When the country is cleared this ice will melt in the spring, and the minimum temperatures will be considerably higher.

There is reason to believe, however, that the summer of 1904 was unusually cold in the clay belt. Mr. T. B. Speight, O.L.S., in the report of his explorations in this region in 1900, says that only two frosts occurred during the whole of that summer. Again, Mr. G. F. Kay, B.A., reports concerning the temperature of the same region for the summer of 1903, that no frosts occurred between 17th June and 1st September.

The whole region which this report concerns is south of the forty-ninth parallel of latitude, which constitutes the southern boundary of Manitoba. Hence, from considerations of latitude there is no reason why the climate of this region should be more severe than that of southern Manitoba.

That certain vegetables and fruits can be grown in this region even at the present time is known by experiment. An Indian who lives on the western shore of Frederick House lake has fair success in raising potatoes, even though he merely throws the seed on the ground, covers it with a little soil, and then pays no attention to his garden until he digs up his crop in the autumn. At Fort Matachewan, according to Mr. Lafracain, potatoes grow well, as also rhubarb, lettuce, radishes, onions, carrots and cabbages. Some seasons pumpkins and cucumbers do well. Mr. Miller, of Fort Mattagami, tells a similar story. He has succeeded in growing some of the smaller fruits as well as many vegetables.

Rainfall

June and July in the Clay Belt in the summer of 1904 were good growing months, with plenty of sunshine and a sufficiency of rain. August was a duller month, and had a greater rainfall. September was a very wet month with numerous rain storms, and, on the twentieth and twenty-first days, snow flurries. It is an interesting fact that thunder storms were noted on only three occasions, 17th June, 17th July, and 28th August, and these were of the mildest possible nature, when compared with the frequently heavy electrical storms of southern Ontario.

Seasons

Mr. James Miller and Mr. S. Lafricain, Hudson Bay Company factors at Forts Mattagami and Matachewan respectively, say that winter sets in about the middle of November, and that the snow disappears and the ice breaks up about the end of April or early in May. The snowfall amounts to three or four feet. Thus it would seem that winter in this part of the Province is not much more severe than was that of 1903-1904 in southern Ontario, and that it resembles very much the ordinary winter of Manitoba.

The Clay Belt summer is somewhat shorter than that of southern Ontario. The fact that it is about three weeks later is shown in the list of flora, which gives dates of flowering of plants in both parts of the Province. The early autumn is shown in the temperature record.

III. FLORA

The plants named in the following list were identified by the aid of Gray's Manual of Botany. In some cases it was impossible to be certain of the diagnosis because of the scant literature at hand, and on account of varieties in the Clay Belt not yet described. The names of such plants are marked with an asterisk.

The date of identification, which in most species is approximately the first date of flowering, is given alongside the name of the plant, together with, in many cases, the first date of flowering of the same plant in the vicinity of Guelph. The latter dates were kindly supplied by Mr. A. B. Klugh, secretary of the Wellington Field Natural-

ist Association, to whom I here tender my thanks. A comparison of a large number of the dates of flowering shows that the summer of the Clay Belt is from two to three weeks later than that of southern Ontario.

Flora of the Clay Belt

Plant	Clay belt	Guelph
Sambucus racemosa	June....5	May ...15
Viola blanda	" 6	" 3
Trillium grandiflorum	" 7	" 8
Louicera ciliata	" 7	" 8
Amelanchier Canadensis	" 7	" ...11
Aralia nudicaulis	" 7	June. ..3
Ribes floridum	" 7	May ...22
" cynosbati	" 7	" ...17
" prostratum	" 7	
Menyanthes trifoliata	" 7	" ...23
Actæa spicata, rubra	" 7	" ...30
Claytonia Caroliniana	" 8	Apr....26
Rubus strigosus	" 8	
" triflorus	" 8	May ...23
Caltha palustris	" 8	" 7
Ranunculus abortivus	" 8	" ...15
Trientalis Americana	" 8	" ...27
Mertensia paniculata	" 8	
Streptopus roseus	" 9	" ...27
Salix nigra	" 9	
Trillium cernuum	" 9	
Mitella nuda	" 9	" ...30
Ribes rubrum	" 9	
Anemone nemorosa	" 9	" 3
Andromeda polifolia	" 9	
Smilacina stellata	" ...10	" ...30
Kalmia glauca	" ...10	" ...27
Louicera cœrulea	" ...10	
" involucrata	" ...10	
Ledum latifolium	" ...10	" ...27
Coptis trifolia	" ...10	" ...13
Cornus Canadense	" ...10	June...11
Vaccinium Pennsylvanicum	" ...10	May ...14
Viola rotundifolia	" ...10	
Calypso borealis	" ...10	
Fragaria Virginiana	" ...12	" ...11
" vesca	" ...12	" ...15
*Lathyrus maritima	" ...12	
Clintonia borealis	" ...12	" ...27
Maianthemum Canadense	" ...12	
Sarracenia purpurea	" ...15	June....6
Vaccinium Oxycoccus	" .. 15	" ...26
Comandra livida	" ...15	
Linnaea borealis	" ...16	" ...11
Iris versicolor	" ...16	" 6
Smilicina trifolia	" ...17	May ...27
Cypripedium pubescens	" ...17	" ...30
*Rosa blauda	" ...17	June...13
Geum rivale	" ...17	" 9
Cornus stolonifera	" ...17	May ...26
Osmorrhiza brevistylis	" ...19	June....9
*Ranunculus hispidus	" ...19	
Viburnum opulus	" ...19	
Louicera oblongifolia	" ...20	
Polygonatum biflorum	" ...20	May ...24
Ranunculus Flammula var. intermedius	" ...20	
Pyrus Americana	" ...21	
*Comandra pallida	" ...21	
Oxalis acetosella	" ...21	
Anemone Pennsylvanica	" ...21	
Corydalis glauca	" ...22	
Nuphar advena	" ...22	June...16
Pyrola rotundifolia, incarnata	" ...24	" ...26
Thalictrum polygonum	" ...25	
Galium triflorum	" ...26	" ...14
Pyrola chlorantha	" ...26	" ...14
Cypripedium parviflorum	" ...27	
*Arenaria Grœnlandica	" ...27	
Kalmia angustifolia	" ...30	
Anemone parviflora	" ...30	
Galium trifidum	July 1	" 7
Cypripedium acaule	" 1	" 4
Potentilla Pennsylvanica	" 1	
Pyrola rotundifolia	" 1	
*Louicera Sullivantii	" 1	
Geum strictum	" 1	
Diervilla trifida	" 1	" ...18
Arethusa bulbosa	" 2	July ...28
Goodyera repens	" 2	

Plant	Clay belt	Guelph
Ranunculus septentrionalis	July 4	
Circaea Alpina	" 5	
Potentilla palustris	" 5	June...22
Epilobium augustifolium	" 6	July 6
Pyrola secunda	" 7	
Halenia deflexa	" 7	
Habenaria bracteata	" 7	
Campanula rotundifolia	" 8	June...26
Viburnum cassinoides	" 8	
Pyrola minor	" 8	
Potentilla fruticosa	" ...10	
Pogonia pendula	" ...10	
Cornus paniculata	" ...10	
Habenaria hyperborea	" ...10	
*Epilobium Hornemanni	" ...10	
Sisyrinchium augustifolium	" ...10	
Habenaria dilatata	" ...13	" ...28
*Scutellaria lateriflora	" ...13	
Epilobium lineare	" ...13	
Cypripedium spectabile	" ...14	" ...28
Geum triflorum	" ...14	
*Scutellaria galericulata	" ...14	" ...24
Tofieldia palustris	" ...14	
Moneses grandiflora	" ...18	
Angelica atropurpurea	" ...18	
Monotropa Hypopitys	" ...19	" ...22
Veronica scutellata	" ...21	
Galium asprellum	" ...21	
Nasturtium officinale	" ...21	" ...20
Pogonia ophioglossoides	" ...23	July 5
*Rumex Brittanica	" ...24	
Epilobium coloratum	" ...24	
Monotropa uniflora	" ...24	
Spiraea salicifolia	" ...24	June...29
Mimulus ringens	" ...24	" ...30
Eupatorium ageratoides	" ...24	July ...25
Campanula aparinoides	" ...24	" ...20
Ranunculus circinatus	" ...28	
Lobelia spicata	" ...28	
Polygonum amphibium	" ...28	" ...13
Mentha Canadensis	" ...28	" ...15
Sagittaria variabilis	" ...29	" ...19
Ranunculus Flammula var. reptans	" ...31	
Ranunculus affinis	" ...31	
Aster tardiflorus	Aug 3	
" puniceus var. lucidulus	" 3	
Solidago uliginosa	" 3	
Spiranthes Romanzoffiana	" 4	
Urtica gracilis	" 7	" ...16
Gaultheria procumbens	" 8	
Impatiens fulva	" 9	" ...25
Scutellaria canescens	" 9	
Corydalis aurea	" 9	
Chelone glabra	" ...13	Aug 3
Potentilla tridentata	" ...14	
Bidens cernua	" ...16	
*Hypericum Canadense	" ...16	
Solidago rugosa	" ...16	" 9
Aster macrophyllus	" ...16	July ...25
*Aster Novæ-Angliæ	" ...16	
Stellaria longifolia	" ...17	
Aster multiflorus	" ...25	
Hieracium Canadense	" ...25	
Agrimonia Eupatoria	" ...28	" ...27
Potentilla fruticosa	" ...28	
Prenanthes racemosa	" ...28	
Erigeron acris	" ...28	
Aster paniculatis	Sept ...16	
Betula pumilla		
" glandulosa		
Poa serotina		
Myrica asplenifolia		
Apocynum androsæmifolium		
Calla palustris		
Prunus Pennsylvanica		
Vaccinium uliginosum		
Chiogenes serpyllifolia		
Corylus rostrata		
Typha latifolia		

Rubus chamaemorus.
Crataegus Crus-galli.
Lilium Canadense.
Heracleum lanatum.
Geranium Carolinianum.
Ceratophyllum demersum.

Forest Trees and Shrubs.

Picea nigra.
" " var. rubra
" alba.
Pinus strobus.
" resinosa.
" Banksiana.
Abies balsamea.
Taxus Canadensis.
Larix Americana.
Thuja occidentalis.
Salix nigra (and other sp.)
Populus tremuloides.
" balsamifera.
Corylus rostrata.
Alnus incana.
Betula papyrifera.
" lutea.
Pyrus Americana.
Ulmus Americana.
Fraxinus sambucifolia.
Acer spicatum.

Plants growing in Indian Gardens or on Portages.

Polygonum aviculare.
" dumetorum.
Capsella Bursa-pastoris.
Taraxacum officinale.
Plantago major.
Trifolium repens.
Lepidium Virginicum.
Poa pratensis.
" annua.
" compressa.
Brunella vulgaris.
Erigeron Philadelphicum.
Achillea millefolium.
Graphalium decurrens.
Cnicus arvensis.

Some Cryptograms.

Botrychium Virginianum.
Asplenium Thelypteroides.
Onoclea sensibilis.
Pteris aquilina.
Adiantum pedatum.
Polypodium vulgare.
Osmunda regalis.
Lycopodium annotinum.
" complanatum.
Equisetum pratense.
" palustre.
Marchantia polymorpha.
Many lichens and mosses.

In concluding this section on the flora I would like to call attention to the luxuriant growth of many of the smaller wild fruits. Raspberries in the "windfalls," and red currants in the poplar areas are particularly common, and they attain a size and flavor almost equalling the cultivated fruit of southern Ontario. These fruits ripened about 25 July.

IV. FAUNA

Fur-bearing and Other Animals

This subject has been considered so often that it is hardly necessary to deal with it now. One point of interest, however, must be mentioned, namely, the increase in the number of beaver in this region, beacuse of wise protective legislation. Beaver are now quite numerous in the western part of the region traversed, and, according to the inhabitants of the country they are on the increase.

The skins taken in trade from the Indians at Fort Mattagami during the year ending June, 1904, were, in part, as follows: martin, 300; bear, 15; mink, 300; musk-rat, 2,000; otter, 38; red fox, 10; lynx, 7. Besides these animals, fisher and ermine occur.

Of interest to the sportsman is the fact that moose are exceedingly common. While paddling on a little creek that flows into Moose lake, three were seen in one morning. They seem to be particularly numerous in this localtiy. Red deer and caribou also occur, but are not so common as moose.

Fish

The larger rivers and lakes of the region are very muddy, and for this reason the fisherman must use other means than trolling in these waters. The Indians with nets catch large numbers of pike, pickerel, whitefish, and, in some localities, sturgeon. In the smaller rivers and lakes, which usually have beautifully clear water, pike and pickerel are readily caught with a troll.

Birds

The following birds were seen during the summer:

Canada Jay, Perisorens Canadensis.
Bluebird, Sialia sialis.
Black-headed Gull, Larus atricilla.
American Robin, Merula migratoria.
White-throated Sparrow, Zonotrichia albicollis.
Wilson's Thrush, Turdus fuscescens.
American Redstart, Sedeltophaga ruticilla.
Junco, Junco hiemalis.
Indigo Bunting, Passerina cyanea.
Prairie Hen, Tympanuchus Americanus.
Water Thrush, Seiurus Noveboracensis.
Red-eyed Vireo, Vireo olivaceus.
Phoebe, Sagoruis phoebe.
Rusty Blackbird, Scolecophagus Carolinus.
Blackburnian Warbler, Dendroica Blackburniæ.
Prothonotary Warbler, Prothonotaria citrea.
Yellow-bellied Sapsucker, Sphyrapicus varius.
Nighthawk, Chordeiles Virginiaus.
Belted Kingfisher, Ceryle alcyon.
Northern Raven, Corvus corax-principalis.
Flicker, Colaptes amatus.
Bald Eagle, Haliætus leucocephalus.
Song Sparrow, Melospiza fasciata.
Redpoll, Acanthis linaria.
Cedar Waxwing, Ampelis cedrorum.
Great Horned Owl, Bubo Virginianus.
American Goshawk, Accipiter atricapillus.
Brown Creeper, Certhia familiaris Americana.
Loon, Urinator imber.
White Crane, Grus Americana.
Blue-headed Vireo, Vireo solitarius.
Hudsonian Chickadee, Parus Hudsonicus.
Oven-bird, Seiurus aurocapillus.
American goldfinch, Spinus tristis.
Hermit Thrush, Turdus aonalaschhæ pallasii.
Ptarmigan, Lagopus lagopus.
Ruffed Grouse, Bonasa umbellus.
Canada Grouse, Dendragapus Canadensis.
Golden-crested Kinglet, Regulus satrapa.
Pileated Woodpecker, Ceophlœus pileatus.

The ornithologist will be interested to learn that the prairie hen was found in the region. Only one flock, however, was seen. Several ptarmigan were also observed.

V. CONCLUSION

That this region will be a valuable addition to Ontario's agricultural lands cannot be doubted. It resembles the Temiskaming district in many respects, and the progress of agriculture in this district is a guarantee of the agricultural value of the region under consideration. Its vast extent of clay and clay loam soil, the richest and best-drained being the twenty-five per cent. of the region wooded with aspen, poplar and associated trees; its supply of pulpwood, which will aid the settler in making the "early" years profitable; its spruce, poplar, balm of Gilead and birch, which will provide a considerable amount of timber for export after the needs of the settler are supplied; its jack-pine and tamarack, which will provide material for railway ties; its stores of peat, which, on the development of the peat industry, will afford a valuable supply of fuel; its numerous rivers and streams, which naturally irrigate the country and, as well, afford drainage; its deposits of sand and gravel, and its outcrops of rock, which will be useful for building purposes, and the making of roads; these are some of the factors which will aid in the development of this region as soon as it is brought into connection with southern Ontario, and the rest of Canada by railway construction.

VI. APPENDIX

(1). Chemical Analyses of Soil

The following report on the chemical analysis of the soil samples collected by the writer was made by Prof. Harcourt of the Ontario Agricultural College, Guelph.

"During the last excursion of the Provincial Bureau of Mines Exploration Party into the Abitibi, Mr. A Henderson, B.A., Agriculturist of the party, collected a number of samples of soils typical of the sections passed through. As we could not undertake to analyse all the soils collected, Mr. Henderson selected seven samples, each of which had been gathered in such a way as to fairly well represent the soil characteristic of as many different sections of the country, and submitted these for analysis.

"The following notes on the location and the trees growing on the soil from which the samples were taken were made by Mr. Henderson:

"*No. 5.* From Frederick House river bank at the north boundary of Mann township. Timber—spruce 6 to 8 inches, birch 5 to 6 inches, and poplar 10 inches in diameter, growing about 40 feet high.

"No. 9. From Teefy township. Characteristic soil of the Abitibi river bank, extending from one-quarter to two miles back from river. Heavily timbered, poplar, spruce, balsam, and occasional birch and jack pine, trees large. There is a well decayed covering of humus six inches deep.

"*No. 11.* From Knox township, jack pine soil. Principal trees jack pine, poplar, black spruce, and a few birch, rather small. Very little decaying organic matter on surface.

"*No. 17.* From Teefy township, at Iroquois falls. One of the most common soils in the Abitibi district—a representative soil—along with No. 9 of the river bank and poplar knoll areas of the region traversed. Timber is poplar, spruce and balsam. Poplar grows very large.

"*No. 23.* From bank of creek flowing into Frederick House river near the point where it crosses Niven's line (mile 157). Timbered with spruce, poplar, and balsam, 8 to 15 inches in diameter. Scattered timber, much wind fall. Cedar 12 inches in diameter along water edge.

"*No. 30.* From bank of creek in Knox township. A common soil along creeks and rivers. Luxuriant growth of river hay, willows, alders, etc. Apparently the most productive soil in the Abitibi district.

"*No. 29.* From a tamarack swamp, with a growth of large tamarack (now all dead), and a dense undergrowth of alder shrubs. Sample taken from the top of subsoil, covered by one foot of decaying organic matter. This soil is like that of the black spruce forest, which covers 59 per cent. of the region traversed.

"The following table gives the composition of the soils. The samples were taken below the layer of decaying organic matter, and may, therefore, be considered subsoils.

(2). Composition of Soils from Abitibi District

Constituent.	No. 5.	No. 9.	No. 11.	No. 17.	No. 23.	No. 30.	No. 29.
Moisture	1.4	3.4	0.72	4.30	3.91	5.29	5.15
Organic and volatile	3.9	13.55	3.64	14.83	7.36	18.24	14.27
Insoluble residue	86.3	67.3	68.7	64.8	68.1	54.8	60.81
Iron and aluminium (Fe_2O_3 and Al_2O_3)	6.52	9.23	4.3	12.15	14.45	11.81	13.55
Lime (CaO)	0.795	1.615	0.91	1.285	1.08	1.81	1.58
Magnesia (MgO)	0.51	0.482	0.767	1.34	2.26	0.604	4.41
Potash (K_2O)	0.25	0.75	0.118	0.74	0.864	0.96	0.8977
Phosphoric acid (P_2O_5)	0.115	0.17	Trace.	0.143	0.105	0.238	.24
Total nitrogen	0.087	0.387	0.07	0.297	0.12	0.512	.157
Humus	1.28	6.98	0.90	5.05	1.07	6.42	8.21

"The above table of analysis does not give definite information regarding the form of combination of the various plant food constituents, nor does it tell how much of the potash and phosphoric acid are in an available form; but it does show plainly which soils have enough plant food to rank as good productive soils, provided the physical conditions are right.

"Soil No. 11 is almost totally unfit for agricultural purposes, and No. 5 is hardly up to the minimum limits for good crop production. Fortunately these soils form a comparatively small part of the Abitibi district, and should never be cleared up, but should be kept as forest reserves.

"According to the figures in the table Soil No. 30 should, other conditions being equal, give the best results when it is put under cultivation. This agrees with Mr. Henderson's notes, for he pronounces this the most productive soil in the whole Abitibi district.

"The most important point in connection with these analyses is, however, the fact that soils Nos. 9 and 17, which Mr. Henderson states are the representative soils of the poplar knoll and river bank types of country (25 per cent. of the area explored), are well supplied with lime, potash, phosphoric acid and nitrogen. They are a little low in phosphoric acid, but it must be remembered these samples were taken below the top black mould, and are, therefore, more likely to be poor in this constituent.

"No. 29, representative of the black spruce forest type of country (59 per cent. of the area explored), is a fair soil. The amount of phosphoric acid is somewhat low but potash is very high. This subsoil contained more humus than any of the other soils we have examined, although apparently is was not very well decomposed, because the amount of nitrogen is low. I am of the opinion that this soil would, with judicious treatment, be quite productive.

"It is very doubtful if any of the ordinary soils of older Ontario ever contained any larger amount of the mineral constituents, and there is no apparent reason why these should not be good productive soils."

(2.) Physical Analyses of Soils by Prof. Reynolds, O. A. College, Guelph.

No.	Locality.	Grade.	Sand group.	Clay group.	Coarse gravel.	Org. matter.	Sand group: Fine gravel.	Sand group: Coarse sand.	Sand group: Med. sand.	Sand group: Fine sand.	Sand group: Very fine sand.	Clay group: Silt.	Clay group: Clay.	——
1	From west boundary of Third Township N. of Prosser, spruce forest	Clay	21.22	78.78	1.50	9.00	0.88	2.13	2.83	9.61	6.07	24.30	54.48	Good strong soil, rich in org. matter.
2	N.W.cor. of Third Township N. of Prosser, poplar knoll	Clay loam	27.60	72.40	1.01	3.90	1.53	2.32	3.64	14.05	6.05	43.39	29.02	" " low "
3	From N. boundary of Warden Tp., poplar and birch.	Sand	95.42	4.58	0.12	0.54	2.29	22.00	39.85	30.33	0.95	1.69	2.89	Not much use.
4	From Frederick House river bank at Nieland's Rapids	Sandy loam	61.78	38.22	0.00	3.60	0.00	0.10	0.36	15.09	46.23	22.32	15.90	Light, workable soil, low "
5	" " " at N. boundary Mann Tp	Loam	53.15	46.85	2.17	3.90	0.00	0.18	0.81	23.26	28.90	23.30	23.55	Good loamy soil, " "
6	Couchiching Falls Portage, spruce, poplar and birch.	Sandy loam (gr.)	67.20	32.80	13.75	8.04	8.07	12.68	14.51	23.39	8.56	24.74	8.05	Light and gravelly, but rich "
7	From Frederick House river bank where it crosses Niven's line	Clay	12.00	88.00	0.40	3.00	0.56	1.19	0.81	2.58	6.85	24.40	63.61	Strong clay, low "
8	From N. boundary of Third Tp. W. of Tully Tp. heavy birch, spruce, poplar	Loam	60.24	39.76	0.00	4.98	0.00	0.00	0.00	20.40	39.84	31.30	8.46	Fairly good loam, medium "
9	From Teefy Tp., characteristic soil of Abitibi river bank	Clay	13.20	86.80	0.00	10.12	0.36	2.25	2.91	3.79	3.86	29.89	56.94	Strong clay, rich "
10	From township W. of Mann, poplar knoll	Clay loam	34.25	65.75	0.85	1.82	0.72	1.88	0.79	15.82	15.54	42.15	23.60	Medium clay loam, poor "
11	From Knox Township	Clay	12.10	87.90	0.00	0.55	0.76	1.22	0.98	5.20	3.95	53.40	34.49	Strong clay, " "
12	From the extensive brulé of Mann Tp., spruce forest.	Clay	13.94	86.06	0.30	6.40	0.35	1.89	3.94	3.79	3.97	36.01	50.05	" medium "
13	From a depression 3 chains wide between two rock ridges Knox Tp.	Clay loam	35.72	64.28	0.82	6.66	1.35	3.07	5.12	22.91	3.27	20.14	44.14	Medium clay loam " "
14	From Calvert Tp., poplar knoll	Loam	56.89	43.11	0.22	4.00	0.66	2.00	2.08	20.42	31.73	28.48	14.63	Light loam " "
15	From N. boundary of Warden Tp., jack pine area	Sand	89.64	10.36	0.00	2.20	2.78	28.18	32.37	23.58	2.73	4.40	5.96	Not much use.
16	From Second Tp. W. of Mann, poplar knoll	Clay	17.05	82.95	4.20	2.62	0.87	1.79	1.47	7.62	5.30	47.37	35.58	Strong clay poor "
17	Teefy Tp. at Iroquois Falls (a common soil in clay belt)	Heavy clay	7.08	92.92	0.00	10.00	0.00	0.30	0.20	3.17	3.41	22.44	70.48	Very heavy rich "
18	From Prosser Tp., poplar knoll, another common soil	Loam	47.44	52.56	20.81	10.00	9.04	11.14	7.31	12.45	7.50	27.09	25.47	Good medium loam " "
19	From Rickard Tp., Abitibi River bank	Clay loom	27.85	72.15	0.10	2.32	3.08	3.11	2.12	6.95	12.59	34.62	37.53	Good clay loam poor "
20	From Edwards Tp. (a common soil) poplar knoll	Heavy clay	10.85	89.15	0.00	6.58	0.32	0.92	1.33	4.51	3.77	31.98	57.17	Very heavy medium "
21	From Abitibi river bank at Buckdeer Rapids	Sandy loam	65.86	34.14	0.00	2.77	0.00	0.16	2.11	48.77	14.82	12.88	21.26	Light poor "
22	From W. boundary Prosser Tp., poplar knoll	Clay loam	26.21	73.79	2.63	6.92	2.05	3.69	4.13	11.44	4.90	37.12	36.67	Strong clay loam, medium "
23	From bank of creek flowing into Frederick House river, near Niven's Line	Clay to heavy clay	11.36	88.64	0.00	5.82	0.86	1.76	1.90	1.92	4.91	31.25	57.40	Very heavy " "
24	From Edwards Tp., spruce and poplar	Clay to heavy clay	10.70	89.30	0.00	10.00	0.08	0.41	0.68	5.44	4.09	12.12	77.18	" rich "
25	From high, sloping bank of small lake in Tp. W. of Tully	Loam	44.95	55.05	3.44	1.60	1.45	3.80	7.80	22.40	9.50	17.70	37.35	Medium loam poor "
26	From Calvert Tp., poplar knoll	Loam	39.62	60.38	0.00	6.76	2.31	8.72	8.19	13.27	7.13	4.32	56.06	" medium "
27	A typical tamarack swamp	....	*	....	....	....	....	....	....	....	....	....	....	....
28	From same bank as sample 5, 10 lower down, 10 feet nearer river level	Clay	22.91	77.09	0.74	3.68	0.55	1.80	2.18	4.94	4.42	31.60	45.49	Medium clay, low in org. matter
29	Tamarack swamp, subsoil N. Abitibi River, opposite mouth of Dokis	....	....	....	....	....	....	....	....	....	....	....	....	Whole sample taken by Chemical Department.
30	From bank of creek in Knox Tp. (most productive soil in Abitibi country)	Clay	23.55	76.45	0.00	12.35	2.34	6.87	3.08	4.76	6.50	35.87	40.58	Medium clay, very rich in org. matter
31	Peat sample	Nearly all humus.	....	....	....	92.47	....	....	....	....	....	....	....	....
32	From Little Tp., jack pine, plain soil	Light sandy loam.	89.69	10.31	3.58	1.50	10.59	33.94	32.08	11.21	1.87	5.72	4.59	Not much use.
33	A common soil, spruce and birch	Clay	18.49	81.51	0.00	7.42	0.63	3.85	3.46	6.49	3.06	34.46	47.05	Strong clay, rich in org. matter
34	From bank of small lake on N. boundary, Third Tp. W., poplar knoll	Clay loam	39.10	60.90	0.53	2.20	1.62	2.78	3.64	15.12	15.95	42.45	18.44	Medium clay loam, poor "

35	From N. bank of Porcupine R. in Gowan Tp..........	Clay loam.........	31.10	68.90	0.00	9.06	1.07	2.02	1.76	8.09	18.16	53.55	15.34	Medium clay loam, rich in org. matter		
36	From Wesley Tp., black spruce forest subsoil, 14 inches mould above	Heavy clay........	2.89	97.11	0.00	6.07	0.00	0.00	0.33	1.75	0.81	15.44	81.67	Very heavy	medinm	"
37	Black spruce forest subsoil	Clay	17.27	82.73	0.00	9.45	0.59	1.97	2.23	7.82	4.66	28.33	54.40	Strong clay	rich	"
38	From Mann Tp., black spruce forest subsoil under 18 inches mould..........	Clay	17.40	82.60	0.01	7.43	1.83	2.25	1.60	4.78	6.94	39.18	43.42	"	"	"
39	From Abitibi R. bank..........	Clay loam	32.25	67.75	0.00	5.85	2.[illegible]5	10.32	6.61	8.58	3.99	10.10	57.65	Medium clay loam,	medium	"
40	From Nieland's Rapids, Frederick House river bank.	Clay	21.20	78.80	0.00	8.72	0.18	2.10	1.76	3.10	14.05	38.66	40.14	Medium clay	rich	"
41	From Rickard Tp., jack pine plain..........	Light sandy loam .	77.54	22.46	0.13	3.70	0.00	2.44	14.08	55.32	5.71	7.02	15.44	Very light	low	"
42	From Second Tp. N. of Tully, poplar knoll..........	Clay	12.66	87.34	0.00	1.82	0.32	1.47	1.96	4.79	4.12	32.05	55.30	Very heavy	poor	"

* Incapable o definite analysis on account of humic acids.

Of samples sent 5 per cent. were heavy clay ; 39 per cent. of clay 19 per cent. o clay loam ; 15 per cent. of loam 7 pe cent. of sandy loam ; 5 per cent. of light sandy loam ; 5 per cent. of sand ; 5 per cent. of swampy.

N B.—Particles in the samples that are too large to pass through a two millimetre sieve are known as coarse gravel. The dividing line between the clay and silt group on the one hand, and the sand group on the other, is one five-hundredths of an inch for size of particles.

McCANN TOWNSHIP AND N. W. OF LAKE ABITIBI

BY J K WORKMAN

[The following notes descriptive of the township of McCann, which lies west of the Temiskaming and Northern Ontario railway, and north of the Height of Land, and also of the country adjacent to the base line run by O. L. S. Speight in 1904 eastward from the 162nd mile post on the boundary between the districts of Nipissing and Algoma, are by Dr. J. K. Workman, who accompanied Mr. Speight's survey party in the capacity of geologist. Like much of the region in the neighborhood of lake Abitibi, the soil and timber are likely to prove of more importance than possible resources in the way of minerals; and observations of the geology are difficult and scanty owing to the widespread mantle of drift material which effectually conceals the rock formations. T. W. G.]

About the middle of May 1904, I received instructions from Mr. T. W. Gibson, Director of the Bureau of Mines, advising me of my appointment as geologist attached to the surveying party of Mr. T. B. Speight, O. L. S., who would be engaged during the summer in running base lines in the district lying northwest of the Abitibi lakes.

My instructions were to gain all the information possible about the rocks and minerals occurring in the districts immediately adjacent to Mr. Speight's lines, but if it so happened that the district was covered with drift and therefore an agricultural section, I was to devote my time to studying the character of the soil and timber. It was also my duty to note the flora and fauna encountered during the summer.

Mr. Speight notified me that the party would leave Toronto on Friday, 26th May. Deciding to join him there I left Kingston on Thursday and so was enabled to have an interview with Mr. Gibson, receiving more detailed instruction and some instruments for use during the trip. Mr. Speight's party did not leave on Friday, as planned, on account of the heavy rainfalls earlier in the week; however they arrived at New Liskeard on Tuesday's boat. We left next morning via steamer Geisha but had to transfer at the mouth of the Blanche river to the steamer Ville Marie, as we met with an obstruction of logs at this point. We arrived at Tomstown during the course of the afternoon.

On the morning of 2nd June all arrangements having been completed, we left on our trip northward in five Peterborough canoes. There were seventeen men in the party, all told. We made good time going in. Ascending the Blanche river we passed through Round and Kenogami lakes, then continuing up Black creek, which is very sinuous, we came to the Height of Land portage. Crossing this, we descended the White Clay and Black rivers to McDougall's clearing, arriving at this point on Friday 9th June, having met with no serious accident or delay. Here we cached most of our provisions, and next day we started south on a canoe route which leaves the Black river at this point for Metachewan post, as Mr. Speight intended to finish subdividing McCann township before commencing his base line work. The series of lakes and portages at this end of the canoe route has already been described by Dr Kay in the Thirteenth Report of the Bureau of Mines.

McCann Township

The topography of McCann township is somewhat diversified. In the northern part the elevation does not vary much. In the central portion west of Grave lake, and east and west of Bethea lake there are a number of ridges which have a general direction of northwest and southeast. Some of these ridges attain an elevation of one hundred and fifty feet or more above the level of the lakes. In the southwest part of the township the ridges do not attain as great elevations, nor do they seem to have any common direction. They are flanked by long easy slopes of sandy soil.

The lakes in the township are six in number. The north boundary of the township cuts across Cherty lake about ten chains from its southern extremity. Grave, Bethea and Gowan lakes have been described by Dr. Kay. Cayea lake lies about three-quarters of a mile east of Bethea lake. It is about fifty chains long and fifteen wide, its longer

axis lying north and south. The sixth lake is about the same size as Cayea lake, but with its longer axis lying east and west. It is situated in lots 9 and 10, concessions I and II. These lakes were all traversed by Mr. Speight while surveying the township, and so can be accurately placed on the map. We found them very useful as they facilitated the work of moving camp to various positions in the township.

ROCK EXPOSURES

There are only a few rock exposures in the township. These are, with one exception, phases of the dolerite described by Dr. Kay; this exception occurred on the top of a ridge one hundred feet high, three-quarters of a mile west of Grave lake. Here the roots of a fallen tree had torn away the soil and laid bare a contact of medium-grained dark dolerite and a light colored granite, the dolerite being superimposed on the granite. The dolerite lay to the south, the line of contact being about east and west. Although a careful search was made no further exposure was seen in this neighborhood.

Four other exposures, all of dolerite, occur in the township: (1) near the west boundary, lot 12, con. II. Here there is a low ridge-like exposure of coarse dolerite, which runs north and south, but soon becomes lost in the glacial drift. (2) On the southwest shore of Bethea lake there is a small exposure of medium-grained dolerite carrying a considerable amount of pyrite. A similar outcrop occurs just across the lake in a northeasterly direction. (3) By far the largest mass of rock exposed in the township is situated east of Bethea lake. It is a ridge-like formation over one hundred and fifty feet high, and about a mile in length, having a general southeast and northwest direction. This rock too is doleritic in character, but has a certain degree of schistosity developed. (4) Along the east boundary from con. II to con. IV, there is a series of outcrops of a ridge of fine-grained pyritous dolerite.

SOIL

The soil of the township is also much varied in character. The northeast and central parts have a good clay soil, but parts of the north and east tracts require draining. The southwest portion has a soil of a sandy nature, but the tops of the ridges are composed of a sandy loam. The tract lying to the southeast has more clay in its composition, but it is rather low and wet, being covered with moss and small bushes. Along the east boundary it is swampy on account of the ridge of rock to the east, which holds the water.

Including the parts that need draining, about sixty per cent. of this township is suitable for agricultural purposes.

TIMBER

The timber of the township is not valuable except for pulp-wood and building purposes, with the exception of the cedar, which grows in the swampy section on the east side. The sandy tracts in the southwest part of the township are sparsely wooded with small Banksian pine. The ridges and the rest of the township are covered with spruce, balsam, white birch and poplar. A few isolated pines and soft maples were also noted. There is quite sufficient timber to meet all agricultural purposes.

On Thursday, 8th July, we finished the township, and the next day we returned to McDougall's clearing. Saturday Mr. Stock, who had been with the party locating veteran's claims, and three of the men started for New Liskeard by the Blanche route. The rest of the party continued down the Black river. For the first five miles the east bank showed evidence of having been burnt over years ago, but the river passes through a good clay area, which seems to be very suitable for agricultural purposes.

Before we reached the Abitibi river we met some other members of the party, who had been away bringing in supplies by the Quinze route, and were on their way to join

us. This part of the Black river and the Abitibi river to the Long Sault rapids has already been thoroughly described in Reports of the Bureau of Mines, namely, by Dr. Parks in the Eighth Report, and by Dr. Kay in the Thirteenth Report; also by Mr. M. B. Baker in the Report of the Exploration and Survey of Northern Ontario in 1900, and by Mr. W. J. Wilson in the Summary Report of the Geological Survey, 1902.

If the soil we saw in passing down the rivers is typical of the district, this will undoubtedly be a very fine agricultural section when the railways are completed and is is opened up and settled.

Work on Base Line

On Monday 11th July we arrived at an Indian's shack on the right bank of the river. Mr. Speight had decided to make this point his base of supplies during the commencement of the base line work. Here we found that the men who had gone ahead of us to cut out a trail from the 162nd mile post on the Nipissing-Algoma boundary to the Abitibi river, had not yet returned.

In order to accomplish something during this enforced delay, Mr. Speight decided to move part of the provisions to another shack at the head of the Long Sault. This was the undertaking in which we were so unfortunate as to lose two men by drowning. Meanwhile we had moved five miles down the river to the point from which the guides had started on their trip to the boundary. As they had not returned by Friday, we commenced our journey to the line by this route. This trail came out at the 166th mile post, so we had to go four miles south to the starting point of the base line work.

Commencing at the river, the first three-quarters of a mile of this trail passed through a wet swampy tract covered with moss, and in places Labrador tea, the timber being entirely spruce. Then we came to the only exposure of rock met with west of the Abitibi, a small outcrop of light-colored, coarse-grained granite. Passing over a slight rise at a distance of one mile from the Abitibi, we came to a river forty feet wide, flowing northward, but it was unnavigable owing to driftwood. Crossing the river we continued in a southwest direction. The soil in this vicinity was a very fine clay, supporting a growth of large timber, mainly spruce, while birch, tamarack, poplar and balm of Gilead.

At a distance of five miles from the Abitibi river we came to a lake one mile long and twenty chains wide, its longer axis being north and south. We continued around the north end of this lake, crossing the outlet, a river forty feet wide. A little further on we crossed a second stream twenty-five feet wide which flowed south and entered the lake.

In the next three miles the ground became higher; the timber however was the same as that east of the lake. Another mile brought us to the line; this last tract was somewhat swampy and covered with moss. The timber, which was all spruce, would average ten inches. The line to the 162nd mile post was of the same character as this last mile of the trail.

On Tuesday 19th July the base line work proper was commenced. The ground was fairly level and covered with moss to a depth of six to twelve inches. The timber was spruce and balsam. At five miles and thirty chains a river half a chain wide flowing northward, was crossed. East of the river the ground became much higher, and we entered a belt of poplar about a mile wide, and extending for several miles both north and south. The seventh and eighth miles passed through a tract much lower in elevation, and consequently wet and mossy, the poplar giving place to spruce and balsam. We now passed over a low ridge, and the ground again became marshy. This condition prevailed until within a short distance of the river, when we came to another ridge wooded with spruce, poplar, white birch and balm of Gilead. At nine miles and fifty chains the river was crossed, about one-quarter of a mile north of the shack at which we had left our first cache.

EXPLORING UNDER DIFFICULTIES

Monday 25th July five men quit work and left for New Liskeard. We moved camp out to the 12th mile post, and on Tuesday Mr. Speight sent two men out to the Hudson Bay Company's post, lake Abitibi, to try to secure more men. This left him very short-handed to go on with the work; in fact for two weeks the party consisted of eight men all told.

East of the Abitibi river the soil is much drier, and the timber, which is spruce, balm of Gilead, balsam and poplar, averages ten inches for the first two miles. Near the 12th mile post we enter a belt of poplar about one-half a mile wide. The timber to the 14th mile post is spruce and balsam. Just before the 14th mile post is reached we come to the Sucker river, which is about twenty-five feet wide, and flows north at this point. The land on both sides of the line from the 14th to the 17th mile post is much higher, and supports a growth of spruce, white birch, balsam, and some poplar.

In the 18th mile this timber gives place to rather small sized spruce. About half a mile to the north there is a small creek, which crosses the line at the 18th mile post. It flows in a westerly direction, and joins the Sucker river. Years ago this creek had been used by beavers, but now the valley is filled up with a growth of black alders and willow. In the 19th mile the timber is much larger, averaging twelve inches, but there is a considerable amount of down timber, making travelling difficult. The line in the 20th mile passes through an open country, which stretches several miles both north and south, and is sparsely wooded with bastard spruce. The remaining three miles of this line is rougher, the timber being mainly spruce, and comes under the classification brulé. This tract extends to the Sucker river on the west, to the 5th mile post on the north, and several miles to the eastward.

Continuing, we now enter a more open section, wooded with spruce and balsam, which average five inches. In the seventh mile the timber is much larger, and consists of spruce, tamarack, white birch and balsam. Adjacent to the ninth mile the ground is covered with a greater depth of moss, and is wet and soggy. This condition prevails to the 12th mile post, except that the timber is much larger in the latter vicinity. In the thirteenth mile the soil becomes much drier. Just west of the 13th mile post is a small lake. This is the first met with east of the Abitibi river. The timber to the 16th mile post is spruce, balsam, poplar and birch, averaging twelve inches.

THE CHIN RIVER

At this point the Chin river is reached, two and a half chains wide, with banks thirty-five feet high. We crossed over on a raft without serious mishap, and camped on the north bank. The timber north of the river is large, spruce, tamarack, birch, balsam, balm of Gilead and poplar, with a considerable amount of windfall.

This part of the Chin river is made use of in the canoe route from the head of the Long Sault to Little Abitibi lake. On Saturday, 20th August, some of the guides reached the camp, bringing in provisions from our cache at the head of the Long Sault, in a birch canoe. I made use of this canoe to make a short exploratory trip up the river. Soon after starting we passed some sharp angular boulders of gneiss in the bed of the stream, their tops being two or three feet above the surface of the water. The river gradually turns to the northeast, and after travelling two miles our course lay due north, then northeast for thirty chains. A short bend to the right brought us to a lake which lay to the north of the river, its longer axis, one-half mile in length, being parallel to the river, *i.e.*, northeast. Continuing up to river thirty chains northward we came to a second expansion or lake, a little over half a mile long and thirty chains wide, its longer axis lying northwest and southeast. The river enters this lake in the southeast corner. We continued eastward up the river; about twenty-five chains from the lake we came to a shack on the north bank, which belonged also to the Indian whose huts we made use of on the Abitibi river. Half a mile above this shack we pitched camp for the night. The next day it rained, but we ascended

the river two miles farther in a southeasterly direction, and came to an extended jam of driftwood. As there was no portage to avoid this, we turned back. Arriving at the northern lake we skirted the shore looking for the portage leading to Little Abitibi lake. In this quest we were unsuccessful.

From the northwest corner of the lake we cut across to the line, arriving at the nineteenth mile post, the distance being three-quarters of a mile. Returning to the canoe, we took it back to where the line crossed the river and camped for the night. In the meantime Mr. Speight had moved to the head of the line, so next day we caught up to him. The timber from the river to the end of this twenty-four miles is large, and similar to that found south of the river. Small lakes are not infrequent in this section.

On Wednesday 24th August the line being finished, we retraced our steps to the 12th mile post and turned on to the base line running west from this point. The first mile was swampy, but in the second the ground became higher. At the second mile post we came to the Chin river again, which here was flowing southwest. Crossing this another half mile brought us once more to the river, now flowing northwest, it having made a long bend. The banks at this point were very high, about forty feet.

The canoe being available for a short trip, I went down the river about three miles. The river had a general northwesterly direction. Ten chains from the line a small mass of gray granite was observed on the west bank. Half a mile down just below two small riffles we came to an outcrop of coarse banded gneiss.

Thirty chains farther on brought us to a low outcrop of granite, making a small bay where the river swerves to the right. A mile and a quarter down there is an exposure of pink gneiss, with a face about twenty feet square, standing out from the river bank.

The banks now become lower, being about five feet high. The timber is good sized spruce, tamarack and balsam. After going three miles we turned back. Going south from the line we arrived at the junction of the Chin and Sucker rivers, about a quarter of a mile up. Turning into the Sucker we passed a portage about twelve chains up, which leads to the head of the Long Sault, taking advantage of a couple of lakes.

A mile up the Sucker we came to a fifteen-chain portage on the left bank, to avoid a series of small rapids.

The river up to this time had a northeasterly course; above a bend its direction was southwest. We turned into a small creek lined with alders. At first our course was south, but gradually turned to the west.

Two miles and a half up this creek brought us to the end of the first portage from the Sault. Here I observed a small group of scrubby Banksian pine. At no other point were any of these trees seen after entering the Abitibi district.

Leaving the canoe here we struck off north across country reaching the line in about two miles. From this point to the Abitibi river, a distance of six and one-half miles, the ground is lightly rolling in character. The timber is medium-sized spruce, birch, balsam and poplar. Two small lakes are passed, the water from each flowing northward. At ten miles and forty chains the Abitibi river is reached, about four miles below the head of the Long Sault. After having finished the remaining mile and a quarter of line, tying in on the 174th mile post of the Nipissing-Algoma boundary, the packers said they were unable to bring provisions down the rapids. As the rest of our base line work was below the Sault, Mr. Speight decided to discontinue operations for the summer.

On Thursday 1st September we started on our homeward trip. Along the banks of the Long Sault, there are a great many exposures of gneiss, and gneissoid and granite boulders occupy the stream and shore.

We returned via the Abitibi lakes and Quinze route, reaching New Liskeard on 9th September.

SOIL OF BASE LINE REGION

The soil along the base line work was all of the same character. With one exception is found in wet spongy places, where a brown muck overlies the clay. In exception it consists of a heavy clay, and would be excellent for wheat growing. The spots it is over seven feet in depth.

In my opinion it is very important that the vegetable mould on the surface of the ground should be worked into the soil, instead of being burnt off when clearing. As the roots of the trees in this district are not deep-seated, this result could be accomplished by using a stump-drawing machine, and burning everything in one place.

CLIMATE

The climate of this district, while now a temperate one, will become milder as it is cleared. No severe frosts were experienced while we were in the field.

There is a scarcity of boulders. A number of gneiss and granite boulders gathered together at one of the Indian shacks where they are used in the manufacture of canoes, presented an unusual sight.

INDIAN OCCUPATION

The Indians all have shacks on these hunting grounds, but they only occupy them during the winter, when they are engaged in hunting and trapping. During the summer months they camp near the Hudson Bay Company's post doing nothing. McDougall on the Black river had a few acres of potatoes, but none of the other Indians had made any attempt to grow any vegetables.

FAUNA

Moose and red deer are plentiful in the neighborhood of the Height of Land. In McCann township we saw several moose, but no red deer. While on the base line work we only saw four moose, but their tracks were plentiful in places. Cariboo are very scarce, according to the Indians. We did not see any all summer. Only three black bears were actually seen, but tracks and fresh work were noted almost everywhere. This was particularly evident on the journey out. The soft clay borders of both banks of the Abitibi river, left dry by the low water, had been tramped over for miles by bears in their search for berries.

Beaver trails and work were noted along the base lines, but these intelligent little animals are scarce in this district.

No porcupines or skunks were seen, but one ground-hog was trapped by the guides.

Rabbits were not plentiful this year.

Partridges are not abundant, but may be found almost anywhere. Black, red-headed and wood duck were observed in Abitibi river.

Other birds noted were the Canada bird, woodpeckers, cedar bird, canaries and warblers, sandpipers and plover, least bittern, owls and ravens. One lizard and three garter snakes were seen in McCann township.

FLORA

Sedum latifolium or Labrador tea was very common. Yellow water lilies and pitcher plants were abundant. Two varieties of ladies' slipper were numerous, viz,, Cypredium parviflorum and C. creaule. Members of compositae family were common, *e.g.*, daisies, flea-bane, bur marigold, goldenrod, Canada thistle, dandelion, etc. Other flowers noticed were the cardinal lobelia, tuentalis or star flower, sweet briar, and wild roses, blue flags and spotted lilies. Berries were not plentiful, but we found the following varieties: strawberries, raspberries, two varieties of gooseberries, June berries, two kinds of red currants, huckleberries and high bush cranberries.

FISH

We did not catch many fish, but nearly all the lakes contain pike and pickerel. The Abitibi river is almost too muddy for fish to see to take a bait. We only caught a few taulibi and perch in it.

LOON LAKE IRON-BEARING DISTRICT

BY W N SMITH

Within the past year considerable activity has been shown in exploration for iron ore in the Animikie iron-bearing series near Loon Lake, about 26 miles east of Port Arthur. Besides the natural stimulus to exploratory work resulting from the discovery of areas which show considerable concentration of ore, the bounty which the Ontario government offers for domestic ore and the import duty recently imposed by the Dominion parliament upon foreign steel, have given impetus to Canadian prospecting. During the latter part of the summer of 1904 the writer was associated in a somewhat detailed mapping of the Loon lake area, and the following notes are based on observations then made.

The principal exploratory work in the area in question has been done by Mr. Rinaldo McConnell, of Ottawa; Messrs. Knobel and Flaherty, of Port Arthur, and Messrs. Wiley Bros. and Marks, also of Port Arthur, and to these gentlemen the writer is indebted for the fullest opportunity for examining the properties controlled by them, as well as for many personal courtesies. The exploratory work has consisted mainly of diamond drilling and test-pitting. The formations are magnetic only locally where intruded by igneous rocks, and therefore magnetic surveys are not of assistance in locating the areas of concentration.

The location of the area in reference to transportation is exceptionally favorable. The Canadian Pacific railway passes through the district and thus offers a short haul to that company's docks at Port Arthur, and the waters of Thunder bay of lake Superior are but four miles south of Loon lake. From Loon lake to Thunder bay is a descent of 400 feet.

A MESABI EXTENSION

The Animikie iron-bearing series, in which the ore of this area occurs, is the eastward continuation of the Mesabi or Upper Huronian series of Minnesota. Its connection with the Mesabi series has been recognized for many years. The Animikie series first came into commercial prominence some 40 years ago as a result of exploration in it for silver and iron ores, and the considerable production of the former metal.[1] The early explorations for iron, however, were not attended with success, and in recent years comparatively little systematic prospecting for this ore has been done.

GENERAL GEOLOGY

With the exception of the Pleistocene drift, the rocks of the area, so far as can be determined, are all of pre-Cambrian age. The succession is as follows:

Pleistocene ....Glacial drift.
(Unconformity).

Keweenawan (Nipigon)..............Conglomerate, sandstone, marl, diabase sills.
(Unconformity).

Upper Huronian (Animikie)..........Iron-bearing formation and black slates.
(Unconformity).

Lower Huronian.......................Graywacké, greenstone, granite.
(Unconformity).

Keewatin..............................Green schists, greenstone, mashed porphyries.

[1] Report on Mines and Mining on Lake Superior, by E. D. Ingall. Ann. Rept. Geol. & Nat. Hist. Surv. of Canada (new ser.), Vol. III, Part II, 1887-8, Report H.

A summary of the general geology may be given before taking up the iron-bearing horizons.

The Archean rocks are not exposed near Loon lake, but along the Canadian Pacific railway, about 17 miles west of Loon lake, and extending thence in a westerly direction, is a series of greenstones, green schists and mashed porphyries, which lie unconformably below the Lower Huronian graywacké, and which are therefore regarded as belonging to the Keewatin. The general strike of these rocks is east-west, and the dip approximately vertical.

THE SCHISTOSE GRAYWACKÉ

The basal member of the Lower Huronian is schistose graywacké, which, from structural and lithological similarity, is correlated with the Knife lake graywacké-slate formation of Lower Huronian age of the Vermilion district of Minnesota. The general strike of the schistosity is about north 80 degrees east; with which direction the trend of the graywacké ridges conforms. The dip of the schistosity varies from about 65 degrees south to 65 to 70 degrees north. The strike and dip of the true bedding are frequently discordant with the strike and dip of the schistosity. Where igneous intrusion was most intense, and where, perhaps dynamic movement was more severe, the graywacké has been altered to hornblende-schist. In general the graywacké is a medium-grained typical graywacké, but locally it possesses true quartzite phases on the one hand and slaty phases on the other.

Also interbedded with the graywacké near what is believed to be its base, is a considerable thickness of volcanic material, represented by volcanic conglomerates, finely banded tuffs, and amygdaloids. This is best exposed at about the centre of the area east and west between Lambert island and the Canadian Pacific railway.

The most western exposure of the graywacké series is largely represented by a schistose conglomerate containing pebbles of the various phases of the underlying Keewatin, together with fragments of a massive granite and porphyry. The granite pebbles are probably derived from the Laurentian granites, which although not exposed in the area mapped, occur over a considerable area north of Port Arthur. Probably the most persistent pebbles in this conglomerate are vein quartz and black jasper, the latter being derived from the magnetic iron formation which is associated with the Keewatin greenstones and schists of this region. As the contact between the graywacké and the Keewatin is approached, the conglomerate character of the former disappears, and the lowest member of the graywacké very closely resembles the Keewatin greenstones. It, however, can be distinguished from them by the presence of scattered fragmental grains, and by the absence, in the graywacké series, of the minute crumpling at right angles to the general schistosity which is characteristic of the adjacent Keewatin.

GREENSTONE AND GRANITE

Throughout the area the graywacké is intruded by greenstone, also of Lower Huronian age. This greenstone occurs in masses of varying size, but with a general schistose structure parallel to that of the graywacké. In texture it varies from a rather uniform fine-grained to a coarse, massive or porphyritic rock, the porphyritic constituents being largely hornblende. In hand specimens the predominant minerals apparent are feldspar and hornblende.

Large masses of granite cut both the graywacké and greenstone on the south, west and north. The granite is medium-grained to coarse, massive textured, with quartz, feldspar and biotite as the principal mineral constituents. Hornblende is subordinately present, and locally, in pegmatitic phases of the granite, tourmaline is abundant. The granite is nowhere found intruding the Upper Huronian or Keweenawan series, but on the contrary is overlain unconformably by them. While the Lower Huronian age of the granite is thus clear, it is much later than the graywacké-greenstone

series which it intrudes, there having been between the two an interval of time at least great enough to allow of the production of the steeply-inclined schistosity in the former, since the massive textured granite is found cutting directly across this structure. The most complex intrusion, as well as the greatest metamorphic effects of the granite, are found along the north border of the graywacké.

In the central part of the area these Lower Huronian formations form prominent topographic features which well illustrate the relation between the topography and geologic structure of the area. To the north they form a series of disconnected hills with comparatively moderate descent to the valley to the south, in which the railway is located. Continuing south, the graywacké rises abruptly as a long, high ridge, the face of which represents approximately the plane of a steep east-west fault. In contrast with this steep north face of the graywacké ridge is its uniform slope southward to Thunder Bay.

THE ANIMIKIE FORMATIONS

The Upper Huronian, or Animikie, formations are found unconformably overlying all the different members of the lower series. The unconformity is indicated mainly by structural and lithological differences. Structurally, as compared with the underlying series, the Animikie is flat-lying, the general dip to the southeast varying from five to ten degrees. Lithologically, it is distinguished by the comparatively small degree of metamorphism to which it has been subjected. At the base of the series is a rather persistent conglomeratic horizon, varying from a few inches to a foot or more in thickness, the pebbles of which are small and predominantly of vein quartz.

Between the flat-lying beds of the Animikie has occurred the intrusion of laccolithic sills of diabase, to which by subsequent erosion the very characteristic hills and ridges with vertical diabase caps owe their origin. These laccolithic sills represent parts of the great similar intrusions which are found from the Minnesota coast of lake Superior on the west to Nipigon bay on the east, and which form such striking topographic features of the north shore, as the Saw-tooth hills, McKay's mountain, Thunder cape, etc.

THE KEWEENAWAN OR NIPIGON ZONES

Unconformably above the Upper Huronian is a succession of Keweenawan conglomerates, sandstones, and impure marls, to which the term Nipigon series has been applied by the Canadian Survey. This series is most fully developed east of Loon lake. The unconformity between the Keweenawan and the underlying rocks is marked in various ways. At the base of the Keweenawan is a coarse conglomerate, containing water-worn pebbles and boulders of all the underlying rocks, among which, however, granite and iron formation material are predominant. The Keweenawan shows comparatively little metamorphism, even less than the Animikie. The strikes and dips of the Keweenawan are always more or less discordant with the strikes and dips of the underlying formations. The strongest evidence of the great time interval represented by the unconformity is, however, the fact that the Keweenawan is found successively overlying both the Animikie and Lower Huronian formations, thus showing that the entire Animikie and part of the Lower Huronian had been truncated by erosion before the Keweenawan was deposited.

As was noted by Irving,[2] the base of the Keweenawan in this area is represented by a sedimentary series rather than by the great basal igneous masses which are present in the Keweenawan areas to the west and on the south shore of lake Superior. The diabase which forms the laccolithic sills of the Animikie is also found both overlying and cutting the Keweenawan sediments.

[2] The Copper-bearing Rocks of Lake Superior, by R. D. Irving. Mon. U.S. Geol. Survey, No. 5, 1883, pp. 331-332.

The western boundary of the Keweenawan is marked by a steep escarpment which extends in a southwest direction to the head of Thunder bay, and thence along its south shore nearly to Thunder cape.

STRUCTURAL FEATURES

The main structural characteristic of the area is the general dip to the southeast, in this conforming to its geographic position as a portion of the north side of the lake Superior synclinal basin. The upper surface of the Keewatin and Lower Huronian formations shares in the general slope to the south, although as previously noted this does not apply to the bedding and schistosity of the series. The normal strike of the Animikie is to the northeast, with average dip of about seven degrees southeast. Locally, however, the series has been closely folded and the resulting strikes and dips are widely divergent from the normal. The general strike of the Keweenawan is east of north, with flat dip to the southeast, although it also locally shows the same severe folding and fracturing as the Animikie.

Faulting has been an important factor in producing the present structural and topographic features of the district. The faulting is believed to have been caused by the same general forces which produced the lake Superior basin, and was therefore of post-Keweenawan time. As the general movements which formed the lake Superior synclinal occurred, the stresses on portions of the strata were relieved by fracture and accompanying vertical displacement. Thus in this area it is believed that the major fracturing occurred along certain approximately parallel zones, and that in the vertical displacements which followed, the several fracture blocks acted as independent units, in which the north half became elevated relative to the south half, thus producing a system of "block" faults.

The greatest vertical displacement definitely determined is about 300 feet, as shown from diamond drill records and surface exposures along the east-west fault a short distance south of Loon lake.

THE ANIMIKIE IRON-BEARING FORMATION

Four definite horizons are present in the Animikie as follows: (1) a lower iron-bearing member; (2) an interbedded black slate; (3) an upper iron-bearing member, and (4) the upper black slate. These horizons indicate a continuous period of deposition, during which the conditions varied between those of chemical and probably also organic sedimentation, producing the iron-bearing formations, and those of mechanical sedimentation, with the production of the slates. It is believed that the general processes and agencies which produced the iron-bearing formations in this area are analogous to those which produced the iron-bearing members of the ranges on the south shore of lake Superior. These have been fully discussed in the monographs of the United States Geological Survey[3] on these districts, and are too well known to be here repeated. The change from chemical to mechanical sedimentation was not abrupt, as is shown by interstratification of and gradual transition between the two classes of deposits.

The two iron-bearing horizons are themselves quite different in character. The original rock of the upper horizon is a rather thin-bedded, cherty iron carbonate, similar to the cherty iron carbonates of the districts on the south shore of lake Superior. It varies in color from dark gray to very light colored, although the most characteristic phase of the unaltered carbonates is a dark and light banded rock, with the surface exposures usually showing brown limonitic weathering. In texture the formation varies from a dense homogenous rock, in which no definite mineral outlines can be distinguished, to one in which a carbonate cleavage is apparent, although in this latter case it is probable that the coarser carbonate crystals are secondary. A common phase of this horizon is a banded rock composed of alternating layers of iron

[3] Monographs of the U. S. Geol. Survey Nos. 19, 28, 36, 45 and 46.

oxide or partially altered carbonate and light or dark colored or red iron-stained chert. This phase is analogous to the banded ferruginous cherts and slates of the iron-bearing districts of the south shore. All stages of gradation can be observed from the original unaltered cherty carbonate rock through the ferruginous cherts and slates to iron ore.

The total thickness of this horizon is believed to be about 200 to 250 feet. The passage of the iron formation into the black slate above is not exposed in this area, but in the Mesabi district of Minnesota and elsewhere the change has been found to be that of gradual transition, and there is no reason to believe that it is otherwise here. At the base of the horizon however the gradation into the black slate is clearly shown, the iron formation becoming more thinly bedded, finely divided fragmental material appearing and becoming more abundant until typical black slate is reached.

The lower iron-bearing horizon can, except where extremely altered, be readily distinguished from the upper by the constant presence in it of small granules which are entirely absent from the upper horizon. Where the alteration of this rock to hematite has not gone far, it is very similar in appearance to the ferruginous cherts or "taconite" of the Mesabi range.[4] This is especially true where the granules are imbedded in a dense greenish or dark gray silicious matrix. Very frequently, however, in this area, the matrix surrounding the granules is largely carbonate material which varies from exceedingly fine to very coarse-grained. In this it differs from the ferruginous cherts of the Mesabi. Furthermore, although much of the carbonate material in this horizon appears clearly to be secondary, field observation would seem to indicate that part of it is original. The carbonate is not pure iron carbonate, but calcium-magnesium-iron carbonate.

In the Mesabi series the ferruginous cherts are themselves secondary products resulting from the alteration of the greenalite granules of an original "greenalite" rock. Chemically these granules are essentially hydrous ferrous silicate. In the Loon lake area, however, no unaltered greenalite granules were found, but what appear to be to be their alteration products (the granule-bearing rocks above mentioned) occur. Therefore it would appear that in this lower horizon there is represented a considerable period during which there was simultaneously deposited the two compounds of iron—iron carbonate and iron silicate—from which in the ranges of the lake Superior region as a whole the iron ores have resulted. But on the south shore these compounds have not been found occurring together in important amounts. As shown by Leith, in the Upper Huronian iron-bearing series of the Mesabi district, where the source of the ores is ferrous silicate, iron carbonate locally occurs, and in the Penokee-Gogebic district in which a cherty iron carbonate formation, also of Upper Huronian age and at the same stratigraphic horizon, was the original rock, ferrous silicate granules are subordinately present.[5] Therefore it is not surprising that at certain localities, of which the Loon lake area is an example, the conditions should have been such that the two materials were formed at the same time and in approximately equal amounts.[6]

Associated with the granule-bearing rock of the lower horizon, and in part at least secondary to it, are phases which show varying degrees of alteration to or replacement by iron oxide. Of the rocks of the formation which contain a high enough percentage of iron to be classed as ore, two phases are characteristic. One is a fine-grained red or blue hematite of medium hardness. The other is one whose texture is that of a medium to coarse-grained carbonate rock, but with the red color of hematite. That in this latter variety iron carbonate and iron oxide are both present is shown by chemical analyses of certain samples which give higher percentages of iron than is contained in iron carbonate.

4 The Mesabi Iron-bearing district of Minnesota, by C. K. Leith. Mon. U. S. Geol. Survey No. 43, 1903, pp. 116-143.

5 Mon. No. 43, cit., pp. 101, 118.

6 The Iron Ore Deposits of the Lake Superior Region, by C. R. Van Hise. Twenty-first Ann. Rept. U. S. Geol. Survey, Vol. 3, 1901, pp. 319-320.

Conforming to the belief that this lower horizon was deposited close to the Animikie shore line is its comparatively small thickness, between 50 and 60 feet. It is, of course, probable that the thickness increases to the south.

THE CONCENTRATION OF THE ORE

The localities in which the greatest concentration of iron has as yet been proven are included in the area extending four miles west, two miles south and one mile east of Loon lake station. The greater portion of this area does not show outcrops of the Animikie strata, but it is known that the series is present under the overlying sandstone and diabase.

The concentration appears to have been determined by two main types of structural conditions:

(1) In the one case, the lower iron-bearing horizon is found lying on the south slopes of the graywacké-granite hills, with a comparatively uniform flat dip to the south. During the deformation which the series has undergone, sufficient movement occurred, both across and along the beds, to fracture and open them up, and thus produce conditions favorable for groundwater circulation.

The areas illustrating this type of structure include that portion of the Animikie area lying north and south of the Canadian Pacific railway, and west from Bittern lake about two miles, and the area south of Loon lake and west of Deception lake. In the latter area the iron formation is exposed practically at the surface, there being but from one to ten feet of overlying drift. In the former the lower horizon is generally capped by 10 to 35 feet of diabase. As the thickness of the lower horizon in this district is not great (50 to 60 feet), the question of commercial bodies of ore depends largely on the horizontal element. In both areas exploratory work has been done by test-pitting and diamond drilling. The result of the work thus far done shows that over the greater part of these areas the lower iron horizon has been extensively altered to iron oxide, but that associated with the layers showing the greatest concentration a considerable amount of lean silicious material is present, either as lenses in the hematite or as layers interbedded with it. Thus the average sample of any considerable vertical section is low grade. If it be found practicable to separate the lean material from the good ore, it should be possible to mine a large tonnage from these properties. However, until experiments on such separation have been made on a commercial scale, or until exploratory work has shown a large body of hematite free from lean material, no estimate of tonnage is possible.

Analyses of samples taken every three inches from four exposures representing vertical distances of six to eight feet each are given below. These are from the natural exposures which showed the greatest observed concentration, and include both the hematite and associated silicious material.

Fe.	P.	S.	SiO_2.
45.81	0.020	0.024	31.91
45.22	0.017	0.028	33.13
30.76	0.160	0.058	35.06
30.21	0.256	0.036	37.11

(2) The second structural condition which determined concentration is that of severe local deformation. This is mainly shown at or near the fault planes, where the movements have produced closely folded and brecciated rock masses. Here the conditions were again favorable for the circulation and work of ground water.

This phase of deformation is best illustrated in the Animikie area lying along the fault plane north of Deception lake and extending eastward to Silver lake, the area east of Deception lake, and that portion of the Animikie area located south and

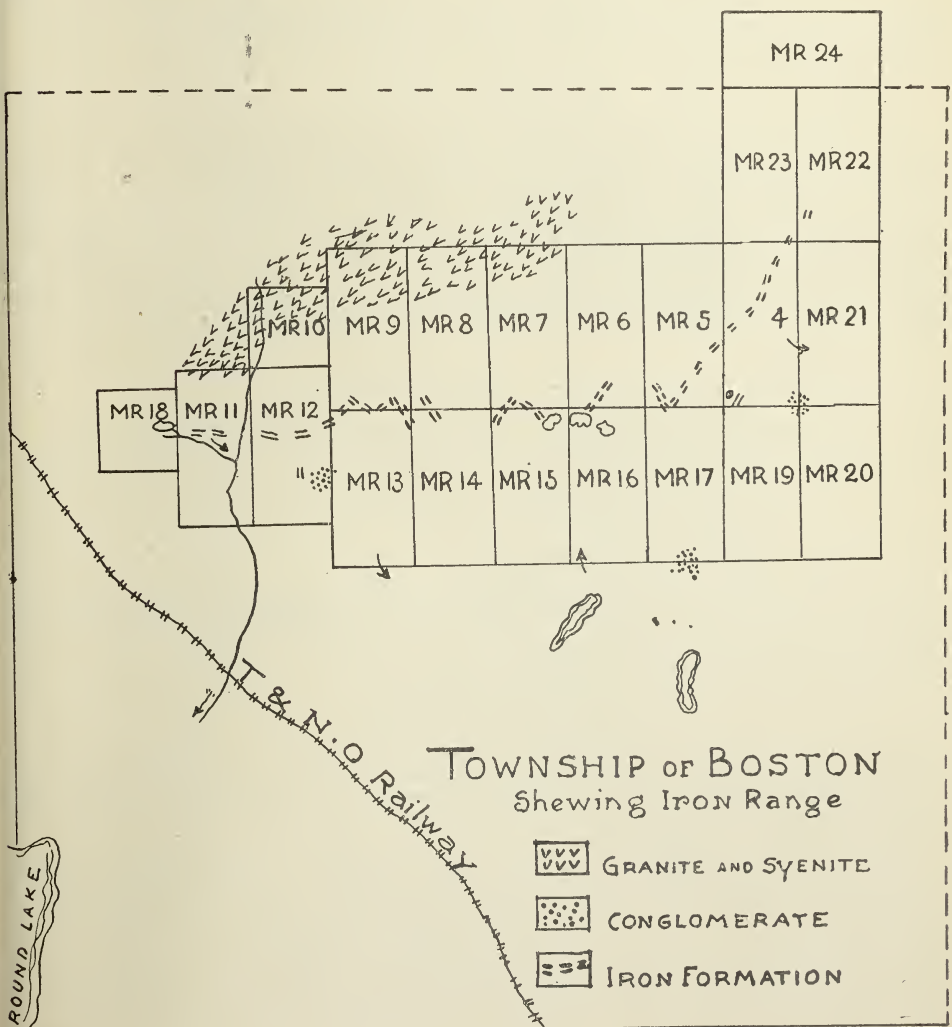
east of Bittern lake. On the above properties at various places both the upper and lower horizons of the iron formation are exposed. In these areas diamond drill holes have been put down, but the main work has been by test-pitting and driving short drifts into the iron formation on the hill sides. As in the previous case, the iron formation is found to be largely altered to iron oxide, but here also the layers showing the maximum concentration are frequently interbanded with lean material, or in the more brecciated phases contain masses of chert irregularly through the ore. The important question is again that of the economic separation of the lean from the commercial grade material.

The alteration of the iron formation has occurred both before and since Keweenawan time. The evidence of the pre-Keweenawan alteration lies in the abundant fragments of ferruginous chert and iron ore which occur in the Keweenawan conglomerates; that of the later alteration in the fact that the deformation which produced fracturing and brecciation of the iron formation, and which in part determined the concentration, was later than the Keweenawan time, as is shown by the similar phenomena of deformation in that formation.

BOSTON TOWNSHIP IRON RANGE

BY WILLET G MILLER

Two or three years ago an iron range was discovered in the township of Boston, which lies about fifty miles a little west of north of the town of New Liskeard, district of Nipissing. As the Bureau had no information concerning this range, it was decided to make an examination of it in the month of October last. We accordingly left Haileybury by steamer for Tomstown, and thence canoed up the main branch of the Blanche river to Round lake. From the northeast corner of this lake we portaged into the locations which had been surveyed. These locations are numbered M R 4 to M R 24 inclusive.



There being no trail from Round lake to the locations, it was necessary for us to find a route of our own. This we succeeded in doing without very much trouble.

It was found that the iron range has a crescent shaped form, curving from the northeast locations gradually south and west through the central locations; then turning northwestward it approaches the northeast corner of the township of Otto. Our work showed that the iron-bearing formation could have been covered by surveying out a much smaller area than has been applied for in Boston. The strike of the iron formation in the outcrops along the central east and west line of the locations is variable.

The township of Boston has been so thoroughly burned over that one has difficulty in getting firewood in places, especially in the autumn, sufficient to last for two or three days when camping in one spot. The central part of the township is high and rocky. From the central east and west line of the locations one can see mount Chanmanis and other hills which lie at a distance of twenty-five miles or more to the northeast.

There are a number of small lakes and streams on the locations which have been surveyed, and we were struck by the great number of beaver dams, still in use, which are to be found at the outlets of the lakes and along the courses of the streams.

GEOLOGY OF BOSTON

The rocks in this township belong to the pre-Cambrian, and consist of more or less altered and disturbed greenstones, quartz porphyry and related types. These cover practically all the southern two-thirds of the township. Part of the northern and northwestern portion of the township is occupied by granite and syenite, which cut the complex of igneous rocks just mentioned. There are some small exposures, or what may be called remnants, of a fragmental series. According to the nomenclature now proposed by the Geological Surveys of the United States and Canada, the series in this township would be represented in tabular form as follows:

Pre-Cambrian:

Trap dikes: Age uncertain.

Lower Huronian: Represented by small outcrops of conglomerate.

(Great unconformity).

Keewatin: Greenstones, quartz porphyry, etc. The iron formation is associated with the greenstones.

(Igneous contact).

Laurentian: Granite and syenite.

As the writer has not made a laboratory study of samples of all these rocks, the above brief description may not be strictly correct from the scientific point of view, but it will serve for economic purposes.

THE IRON FORMATION

The iron formation or jaspilyte in Boston is similar in character to that of Temagami and to those of other parts of Ontario, such as the Hutton township range, north of Sudbury, the Mattawin range west of Port Arthur, and the Vermilion range of the state of Minnesota.

The formation consists of iron ore, which in Boston is magnetite, interbanded with jasper and other closely related silicious material. Such an interbanded formation is known as jaspilyte. This formation has a length in Boston of approximately seven or eight miles. Another point in its favor, in addition to its length, is that it has been subjected to considerable disturbance by intrusions of igneous rocks. It has been much more disturbed than has the Temagami range or almost any of the other ranges which the writer has examined in Ontario or in the Lake Superior

region of the United States. To counterbalance these points in its favor, that is its length and its disturbed condition, we have to consider that its breadth is much less than that of the Temagami range or that of many other Ontario ranges. Some of these ranges have widths of 1,000 or 1,500 feet. Frequently their width is 500 or 600 feet. The width of the Boston iron formation is usually not more than 90 or 100 feet. The greatest width we saw in the township was about 300 feet. It would appear that the Boston range had originally a much greater width, but that it has been split up and separated by intrusions, and on this account presents comparatively narrow exposures.

LOCATION OF THE RANGE

Heretofore the township of Boston has been somewhat inaccessible, necessitating a canoe trip of about two days' duration from the steamboat landing at Tomstown on the Blanche river. The line of the Temiskaming and Northern Ontario railway has, however, been located across the western side of the township, and the road is now under construction almost to its southern boundary. The road runs very close to the western edge of the iron range.

OUTLINE DESCRIPTION OF THE LOCATIONS

The following description is copied from notes taken, from day to day, while in the field. Since some of the locations, numbered M R 4 to M R 24 inclusive, were visited on two or more occasions the references to them have been repeated.

The first point at which we encountered the survey lines of the locations when portaging into the range was on the southern boundary of M R 13, 300 yards east of the southwest corner post. From Round lake to this point the rock is the old greenstone of rather dark color, and more or less schistose structure. Near the location the color of the rock changes somewhat, becoming lighter, and having the appearance of an altered variety of a more acid type; it may, however, be a metamorphosed fragmental variety. At the point on the line referred to, the old light colored rock is cut by numerous small dikes of trap and also by granite like that which outcrops at Round lake.

Northern Boundary of Locations

Two hundred yards east of the northwest corner of 11 granite outcrops on the line and extends to the creek at the corner post, which is the northwest corner of 12. Going up the west boundary of 10, granite dies out in 100 yards, and the old dark rock, rusty in appearance, comes in about 200 yards up the line. The creek here runs north about parallel with the line and a little to the east. There is not more than about 100 yards of the old dark rock outcropping on this line. Most of the surface is occupied by a hornblende syenite which gradually becomes coarser in grain as we go north, resembling a boulder seen to the southward. The feldspar tends to take on a porphyritic structure. On the south edge there are occasional inclusions of a dark rock in the syenite. Two hundred yards east of the northwest corner of 10 the creek crosses the line. The syenite continues on the line eastward across the creek to the northeast corner of 10. From this point syenite outcrops to the northwest corner of lot 9. Thence it continues to the northeast corner of 9 and on to the northeast corner of 8. Across the northern boundary of 7 the syenite outcrops to within about 275 yards of the northeast corner post of this location, when some of the hornblende rock comes in and is seen to be cut by syenite. The corner post here is in a swamp. About 150 yards east of the post along the line, a bluff of the altered dark rock rises from the swamp. One hundred and twenty-five yards west of the northeast corner post of 6 there is a hill of rusty rock with much pyrite in places. The rock is quartzite-like, resembling some of that with which pyrite is associated near Net lake, Temagami. From the outcrop of the rusty rock the line runs east across a swamp which has a small stream in the middle of it. From here to the northeast

corner of 5 the line rises gradually up a hill, the surface of which is drift covered. Going up the west boundary of 23, the surface is mostly low and covered. Four hundred and fifty yards south of the northwest corner post of 23 there is an outcrop of rusty rock. Midway on this line a creek is crossed which flows eastward. The west side of 24 is nearly all swampy and covered. A third of the way up from the southwest corner post is an outcrop of the old dark rock, being the only outcrop seen here. On the west one-half of 23 there is only one outcrop also. The outcrop on 24 is just south of a little stream. Three hundred yards farther north is another little stream crossing the line. Along the north boundary of 24 the country is low and swampy. There is a creek crossing the line about 700 yards west of the northeast corner of the lot. A tie-line seems to form a continuation eastward of the north boundary. A trail runs from the creek mentioned southwestward.

East Boundaries of 24, 22, 21

No rock was seen on the north boundary, and there are no rock exposures on the east boundary of 24, the surface being low and more or less swampy. There is a creek within 25 or 30 yards north of the southeast corner of the location. A line runs eastward from this corner post. It is probably a tie-line. The east boundary of 22 from the northeast corner of this lot to within 400 yards of the southeast corner post is rather low and covered. Four hundred yards north of the southeast corner post the Keewatin rocks appear. A little over 100 yards north of the southeast corner post a brecciated-looking rock with matrix of crystalline limestone is exposed for about 50 feet along the line. The east side of 21 is covered for the most part, but there are a few exposures of the Keewatin, chiefly the lighter-colored varieties. The line runs on east from the southeast corner of 21.

South Boundary of 21, 4

Two hundred yards east of the southeast corner of location 4 conglomerate appears and outcrops at intervals to the post. Fifteen feet southeast of the post there is a bed of rock, which weathers like impure crystalline limestone, in the conglomerate. It has a width of about 6 feet and strikes northeast. There are also narrower bands of the same rock in the conglomerate. This limestone-like variety resembles rock seen in other parts of Boston, the character of which was not definitely determined. A road or trail crosses the line about 125 yards west of this post, and runs in a direction northwest and southeast. This is apparently the trail which joins the Blanche river to the southeast.

Northern Boundary of 18

Across the north boundary of this location the rock, which shows a more or less banded structure, belongs to the Keewatin series. The strike is apparently northwest, and the dip appears to be southwest at an angle of 60°. On the extension of this line westward in the unsurveyed territory the iron formation is seen a little to the south, a short distance west of the post. It is also seen on the east boundary of the township of Otto. These outcrops are small, only 10 or 15 feet in width. Following up the west boundary of the township, a creek was crossed, which is shown on the map on the west line of lot 1, concession 5, of Otto. A little specular hematite was seen just south of a hill. The boundary line is difficult to follow here. Turning west in Otto, the Keewatin series was exposed in numerous bare hills. A few hundred yards west of the line the greenstone schist contains calcite in cracks like those seen in the greenstone near the shore of lake Temiskaming. These cracks appear to have been produced by torsion.

North Boundaries of 11, 12, 13, 14, 15, 16, 17

Going south on the west boundary of 11 the rock appears to be the dark variety of the Keewatin. The surface is pretty well covered. Along the south boundary of this lot much of the surface is also covered. Going eastward from the southwest corner post, a creek is crossed about two-thirds of the way down the lot. Diabase outcrops on the line near the southeast corner post. The other rocks seen were the dark-colored greenstone of the Keewatin. There is a little rust in the rock near the southwest corner post.

Along the south boundary of 12 the rocks are well exposed. They consist chiefly of the dark varieties of the Keewatin, together with what appear to be altered felsite, quartz porphyry and a little newer diabase.

There is a considerable development of the very light-colored or white rock of the Keewatin along the south boundary of 13. This rock is similar in character to some of the pebbles which were found in the conglomerate mentioned a few paragraphs above. It is cut by syenite similar to that in the northwestern part of the township. Both the syenite and light-colored Keewatin are cut by trap dikes. There is a considerable development of trap or diabase a short distance up the west boundary of 13 from its southwest corner. A creek crosses the line about the middle of the southern boundary of 13. The dikes just referred to are immediately to the west of the creek. The old white rock continues to the southeast corner of the lot and beyond.

Across the south boundary of 15 the light-colored Keewatin, with an occasional dike of trap, is exposed. There is a lake about half a mile long, whose greatest diameter lies in a southwest direction 300 yards or so southeast of the southeast corner of 15.

Across the south end of 16 Keewatin rocks are exposed. They appear to be chiefly old traps with occasional dikes of later diabase. There is considerable swamp along the line. A creek flows north across the line 200 yards or so east of the southwest corner of the lot. Two hundred yards east of the southwest corner of 17, blocks of conglomerate with well-rounded pebbles a couple of inches or more in diameter were seen. This rock was not found in place here, but it appears not to have been transported far. Two hundred yards farther east an exposure of conglomerate-like rock with rather angular fragments appears. About half a mile south of this is a long narrow lake which strikes southward. The survey lines continue south from both the southwest and the southeast corners of 17.

The east boundary of 17, with the exception of the extreme north and south parts, is low and covered.

West Boundary of 13

On the west side of 13, along the survey line, from the southwest corner for a distance of 640 yards there is an alteration of the old, lighter-colored Keewatin rocks, trap and some felsite. At the 640 yards point there is a knoll of trap with a ravine just to the north.

At 750 yards north the rusty rock, containing considerable iron pyrites in places, comes in, the line running along the east edge of the rusty hill. The pyrites is in the light-colored variety of the Keewatin. At 1,300 yards up the line a little of the rock containing iron pyrites has been broken out just west of the line. The association of rock and mineral along this line is similar to that at some of the Temagami pyrite outcrops.

At about 1,500 yards up the line greenstone or trap comes in. The change, from the white rock of the south to the dark rock farther north, can be seen for some distance from the south. Then trap is passed over till we come to a band of the iron formation which crosses the line 75 yards south of the northwest corner post of 13. There is greenstone on the north edge of this outcrop, which is 35 feet in width and

consists of interbanded magnetite and light-colored silica. The greenstone is cut by a mica-bearing dike.

Near the northwest corner of 13 the more massive greenstone passes into a more disturbed variety, and 600 yards north of the southeast corner of 10 syenite begins to appear. Numerous dikes of this rock are seen along the line about 200 yards to the northward.

Locations 4, 23, 22

Going east along the north boundary of 4 a swamp is crossed. Two hundred yards east of the edge of this large swamp the iron formation begins. This is 300 yards west of the northeast corner of 4. The iron formation is probably 300 feet wide. It is leaner on the west and east sides, and so attracts the needle but little at these points. The strike is about northeast, where it crosses the line between 4 and 23, and the dip almost vertical, approaching the northwest.

Two hundred and sixty-five yards up the east boundary of 23 the iron formation crosses the line into 22. It appears to strike more north than northeast here and probably has a similar strike at the outcrop last mentioned.

Down the east boundary of 4 much of the surface is drift covered. A small stream is crossed about two-thirds of the way down the line. There are exposures of the older series and of the newer greenstones. Twenty yards north of the southeast corner post of 4 conglomerate, already referred to, outcrops and continues south to the post. It strikes northeast. Pebbles are abundant and vary in size up to about 3 inches.

West along the south boundary of location 4 the first 150 yards is probably conglomerate, being more or less covered, and then Keewatin greenstone rises into a hill. A little rust is seen in the rocks just east of the post. Going west along the line there is considerable rusty rock on the east half of the half mile with boulders of jaspilyte. Westward, 150 yards east of the southwest corner of 5, the jaspilyte comes in in outcrops of considerable width.

Mr. McCamus traced the iron formation southwest from the northeast corner of 4. It appears to cross the boundary of 5 and to be split up, an outcrop occurring near the camp in 4. Here, in the southwest corner of 4 about 25 yards southeast of a shanty, the jaspilyte is cut by two dikes. The band of iron formation here is about 200 feet wide. A mica trap dike runs northwest approximately and averages 6 to 10 feet in width. At its southeast end it cuts a felsite dike, which also cuts the iron formation and runs southwest approximately. The width of the latter dike is about 6 feet. The trap dike holds inclusions of granite, as does the smaller dike near by. A little creek cuts across the iron formation to the east, and the country is covered along the course of the iron formation to the eastward. To the north are large outcrops of rusty-weathering rock.

South Boundaries of 5, 6, 7, 8, 9

Following the southern boundary of 6 and 7 a trail is seen running along the north of the line to avoid a hill and a small lake. On the east end of the southern boundary of 6 is a high hill from which the country can be seen for miles around. Mount Chanmanis, which lies a short distance east of the inter-provincial boundary line near the forty-second mile post from lake Temiskaming, looms up with its characteristic haystack form.

Three of the outcrops of jaspilyte in location 6 along its southern boundary strike north and northeast. Outcrops are seen in 7 and one in 8, 100 yards east of the post. The strike was northwest and the dip, which was almost vertical, was to the east. The outcrop is about 25 feet in length. Near the southeast corner post of 9 there is a small outcrop of the iron formation, 5 or 6 feet wide. Its strike is northwest. On the same location, 200 yards west of the post, is an outcrop about 30 feet in length. The

strike is northwest. Fifty yards farther west is an outcrop which has a strike northwest and a width of about 30 feet. There appears to be one band which has been broken up by greenstone. In the swamp a short distance west is a mass of iron formation 10 or 12 feet in diameter, which might not be in place. Along the line for 100 yards or so east of the southwest corner of 9 the jaspilyte shows in outcrops a few feet in width and is much disturbed.

There is a swamp on the west half of 8. No outcrop was seen or determined by the dip needle 200 yards south of the east and west line or to the northward between lots 7 and 8.

Going north on the line between 7 and 8 the syenite is met with a quarter of a mile south of the north boundary. A rusty band lies to the south. The syenite rises into a hill along the north boundary.

Locations 11, 12, 18

Going west on the line between 10 and 12 a few feet of banded iron ore is seen 150 yards west of the corner post. At 264 yards a band has a width of 3 or 4 feet, and the strike is parallel with the survey line for a few yards. There is a creek at the northwest corner of 12. The post is situated on the west edge of the creek.

Four hundred and forty yards north of the southeast corner of 18 there are a few feet of banded ore which shows at the outlet of a creek which comes from a lake in 18. This lake lies immediately west of the line, and is not shown on the published map of the township. The gorge of the creek lies in the iron formation. There is an interesting little beaver dam across the creek at this point. Just southwest of this dam the banded rock is much wider than at the dam itself.

Jaspilyte outcrops across 11 and 12, between the east boundary of 18 and the west of 13. On 11 on the east face of the hill near the centre of the lot facing the creek bottom there is an exposure of jaspilyte with a total thickness of about 90 feet, interbanded with which are three layers of rock each about 4 feet wide. On lot 12 on the face of the hill, facing west into the creek bottom, is about the same width of jaspilyte. The iron formation seems to split up here, one part running east to the 35 feet band on the west boundary of 13, and the other north to the south boundary of 10.

The iron formation runs south in 12, and outcrops 300 yards west of the 600 yard point north of the southwest corner of 13. It occurs on both sides of the north and south line between 11 and 12 in this part of the field.

The distribution of the outcrops of the iron formation in 12 illustrates the disturbance to which it has been subjected in Boston. Three have been referred to in the location; one crossing the line between 12 and 13, near the northwest corner of the latter; another on the line between 10 and 12, about 200 yards from the northeast corner of 12; while a third outcrop is that referred to above. It lies 300 yards west of a point on the west boundary of 13, the point being 600 yards north of the southwest corner post of this location.

Conglomerate appears 300 yards west of the 600 yard point north from the south end of the west boundary of 13.

CONGLOMERATE

The conglomerate outliers which were met with, as shown by the above description of the locations, are three in number, if we except one which has a matrix of crystalline limestone. These are (1) at the southeast corner of 4, (2) on the southern boundary of 17, (3) on the south half of 12.

This conglomerate probably was at one time a widespread formation here but has been removed by erosive agencies. It is probably of the same age as that in which the cobalt-silver veins occur near lake Temiskaming. The township of Boston lies at a greater elevation than the outcrops near Temiskaming. Hence its surface has been subjected to more severe erosion.

ROCKS NEAR ROUND LAKE

Some of the rocks in the vicinity of Round lake and in the township of Otto are described in a report made by Mr. L. L. Bolton to the Bureau of Mines, and published in the 12th Annual Volume.

The present writer did not spend much time around the lake but made the following notes:

The rock near the south end of the east boundary of Otto is syenite with dark inclusions which are more or less rounded. These dark patches no doubt represent fragments of the Keewatin which have been enclosed and partly absorbed by the intrusive granite magma. Going around the eastern edge of Round lake similar outcrops are seen. Continuing the canoe route down the river, the rock seen on the shores is chiefly granite, with dark inclusions, to the point where the north branch joins the Round lake branch of the Blanche.

PRE-CAMBRIAN NOMENCLATURE[1]

[Introductory note by C. R. Van Hise]

The report below of the special committee on the nomenclature and correlation of the geological formations of the United States and Canada is the first joint report of the geologists of the two countries. Before the death of Dr. G. M. Dawson, formerly director of the Canadian Geological Survey, I had correspondence with him in reference to joint field-work in the lake Superior region. It was agreed between us that such field-work should be undertaken, but his untimely death occurred before anything was done.

After Dr. Dawson's death I continued correspondence upon the subject with Dr. Robert Bell, acting director of the Canadian Geological Survey. As a result of this correspondence, December 22, 1902, Dr. Bell wrote to Dr. C. D. Walcott, director of the United States Geological Survey, suggesting a conference in reference to the mutual interest of the two Surveys. This letter led to the appointment of a committee—consisting of C. W. Hayes and C. R. Van Hise, for the United States Geological Survey, and Robert Bell and Frank D. Adams, for the Canadian Geological Survey—to consider all questions as to the successions of formations, and as to nomenclature, which concerned the two Surveys.

This committee, with C. W. Hayes as chairman, met for the first time at Washington, January 2, 1903. At this meeting several special committees were appointed to consider different districts along the international boundary. For the lake Superior region the following committee was appointed; for the United States, C. R. Van Hise and C. K. Leith, of the United States Geological Survey, and A. C. Lane, state geologist of Michigan; and for Canada, Robert Bell and Frank D. Adams, of the Canadian Geological Survey, and W. G. Miller, provincial geologist of Ontario.

August 3, 1904, this special committee met in the Marquette district of Michigan, and during the six weeks following visited successively the Gogebic, Mesabi, Vermilion, Rainy lake, Lake of the Woods, Animikie, and original Huronian districts. After finishing the field-work, a report in preliminary form was drawn up.

In December, 1904, another meeting of the special committee was held at Philadelphia, further to consider the report, all members of the committee being present except C. R. Van Hise. At this meeting the report of the sub-committee was completed as given below.

REPORT OF THE COMMITTEE

Your special committee on the lake Superior region, during the months of August and September, 1904, visited various districts in the lake Superior country, their purpose being to ascertain, if possible, whether they could agree upon the succession and relations of the formations in the various districts, and could further agree upon a nomenclature appropriate to express the facts. The districts visited were the Marquette, the Penokee-Gogebic, the Mesabi, the Vermilion, the Rainy lake, the Lake of the Woods, the Thunder Bay, and the original Huronian to the north shore of Lake Huron. Aside from the regular members of the special committee, for parts of the trip other geologists were with the party. Dr. C. W. Hayes, geologist in charge of geology, United States Geological Survey, and a member of the general committee, was with the party for the Marquette, Penokee-Gogebic, Mesabi, Vermilion, and Rainy lake districts. Professor A. E. Seaman was with the party for

[1]Report of International Committee on Lake Superior Geology; from the *Journal of Geology*, February-March, 1905.

the Marquette, Penokee-Gogebic, Rainy lake, Lake of the Woods, and Thunder Bay districts. Mr. J. U. Sebenius was with the party for the Mesabi district, Mr. W. N. Merriam, for the Mesabi and Vermilion districts; Mr. W. N. Smith, for the Thunder Bay district; Mr. E. D. Ingall and Mr. T. D. Denis, for the Lake Huron district. The knowledge of these men was of great assistance to the committee.

In the following pages we shall give the successions and relations of formations which we believe to obtain for each of the districts visited, and give our opinion as to the major correlation of the rock series of the various districts, so far as this can be safely done, and the nomenclature which seems to best express the facts.

For each district, unless otherwise specified, the succession will be considered in descending order. In giving the successions for the various districts, we shall use, for convenience, the names suggested by geologists who have done the detailed work in the districts, without thereby expressing any opinion as to their appropriateness or their advisability.

In the Marquette district we found the upper series there exposed to be as follows: (1) Michigamme slate and schist, and (2) Ishpeming formation. Locally within the Michigamme slate, and apparently near its base, is an iron-bearing horizon. The Clarksburg volcanics, said to be a local phase of the Michigamme formation, were seen at Champion. The basal member of the Ishpeming formation is the Goodrich quartzite. This series, called the upper Marquette series by the United States Geological Survey, has at its base a pronounced unconformity, marked by extensive beds of conglomerate, having materials of diverse character. The dominant fragments of the conglomerate at the localities visited are from the Negaunee formation to be mentioned below. The next series is the Middle Marquette series, consisting of (1) the Negaunee formation, (2) the Siamo slate, and (3) the Ajibik quartzite. In the publications of the United States Geological Survey this series was not separated from the series next mentioned, but the work of Professor Seaman has shown that there is a pronounced unconformity, marked by strong basal conglomerates at the bottom of the Ajibik. Below this unconformity is the Lower Marquette series, consisting of (1) the Wewe slate, (2) the Kona dolomite, and (3) the Mesnard quartzite. At the places where we saw the succession there is a belt of slate between the Kona dolomite and the Mesnard quartzite of such thickness that it might possibly be mapped as a formation if the exposures were more numerous. The members of the United States Geological Survey think that this slate is probably general for the district, as it shows wherever the exposures are continuous from the dolomite to the quartzite. At the base of the Lower Marquette series is an unconformity, marked by conglomerates bearing fragments of all the kinds of rocks seen in the underlying series. Two classes of fragments are especially abundant. These are (1) tuff, greenstone schist, and many kinds of greenstones which belong to the so-called green-schist series of the district, and (2) various kinds of granite and gneissoid granite. Adjacent to the state road south of the city of Marquette the actual contact was seen between the two series, the basal conglomerate resting upon the green schist. The great variety of materials in this conglomerate and the well-rounded character of the fragments left no doubt in the minds of the members of the party that there is a great structural break at the base of the Lower Marquette series.

The lowest group of the Marquette district is a very complex one, which has been designated as the Basement Complex. It consists of two classes of material—the greenstone-schist series, and the granites and gneissoid granites. The greenstone schist series is especially well known through the description of the late George H. Williams, found in Bulletin 62 of the United States Geological Survey. This series is designated on the maps of the Marquette Monograph as the Kitchi and Mona schists. Instrusive in the green schist series are great masses of granite and gneissoid granite. No evidence was seen by the party that any of the granites intrude the sedimentary series above the green-schist series. although Seaman thinks in one

place a small mass of granite does intrude the Lower Marquette series. It is believed that the great masses of granite of the district antedate the three series here called Upper, Middle and Lower Marquette.

In the Penokee-Gogebic district the highest rocks seen are the Keweenawan traps and interbedded sandstones, the bedding of which dips at a high angle to the north. No actual contact between the Keweenawan and the next underlying series was seen, but north of Bessemer, below the Keweenawan, the next formation is the great Tyler slate formation of the Penokee series, while at Sunday lake the Keweenawan rests directly on the iron-bearing formation which is stratigraphically below the slate. This relation led the party to infer the existence of an important unconformity between the two. The Penokee-Gogebic, or iron-bearing series, consists of (1) the Tyler slate, (2) the Ironwood formation, and (3) the Palms slate. This Palms slate was seen to rest directly upon granite south of the Newport and Palms mine. At the former locality there is no conglomerate at the base. At the latter locality there is a conglomerate at the base of the slate which, besides containing granite detritus, also contains many cherty fragments supposed to be derived from the next underlying sedimentary series.

East of the Presque Isle river the lower sedimentary succession of the Penokee-Gogebic district was visited, here consisting of (1) cherty limestone and (2) quartzite. The quartzite dips to the north at a moderate angle and rests upon green schist. The two formations were seen in direct contact for a hundred feet or more. The cleavage of the green schist abuts against the bedding of the quartzite at right angles. The quartzite near its base passes into a conglomerate, which, just above the contact becomes very coarse and contains very numerous well-rolled fragments of the immediately subjacent schist. The unconformity at the base of the quartzite could not be more pronounced.

The party nowhere saw the relations of the limestone-quartzite series just described and the Penokee-Gogebic series proper, but they have no reason to doubt the conclusion of the United States Geological Survey that the limestone-quartzite series is the inferior one.

The relations of the green schist, called Mareniscan by the United States geologists, and the granite, which together constitute the basement upon which the determined sedimentary series of the dictrict rest, were not studied by the party. The United States geologists hold that the relations are perfectly clear, and that the granitic rocks are intrusive in the green schist.

In the Mesabi district the succession of the Mesabi series is as follows: (1) Virginia slate, (2) the Biwabik iron formation, and (3) the Pokegama quartzite. This series dips at a gentle angle to the south. At the base of this series at Biwabik is a conglomerate which rests upon a series of slates and graywacké, the latter in nearly vertical attitude. The unconformity between the two is most pronounced. The slate and graywacké where crossed has a considerable breadth. It flanks a green-schist series. The slate and graywacké formation adjacent to the green-schist is conglomeratic. Many of the fragments of the conglomerate are from the underlying green schists. At the locality visited it could not be asserted that the break between the slate-graywacké formation and the green-schist series is great, although nothing was seen which is contrary to this view. The granite constituting the Mesabi range is reported by the United States geologists as intruding both the green-schist and the slate-graywacké series, but not the Mesabi series. At the east end of the district a newer granite is reported as intruding both the Mesabi and the Keweenawan series, and in the central portion of the district small areas of granite porphyry are reported as antedating the slate-graywacké series.

In the Vermilion district the Upper series, where seen, consists of (1) Knife slates and (2) Ogishke conglomerate. The Ogishke conglomerate contains very numerous fragments of all the underlying formations noted—porphyries, green schists, iron formation, granite—and we have no doubt that there is a great structural break

at the base of the Ogishke. The series below this unconformity, the Vermilion series, consists of (1) the Ely greenstone and (2) the Soudan formation. The Ely greenstone is the dominant formation. It is mainly composed of green schists and greenstones, many of which show the ellipsoidal structure described by Clements. The other important formation of the Vermilion series is the Soudan iron formation. The structural relations of the Ely greenstone and the Soudan formation are most intricate. No opinion here expressed as to their order. The Ely greenstone and the Soudan iron formation are cut by porphyries, and, according to the reports of the United States Geological Survey, are cut in a most complex way by the great northern granite, but the localities ilustrating this were not visited. It is worthy of mention that the United Sates geologists report granite as intruding the Knife slates and Ogishke conglomerates in the central parts of the district, especially in the vicinity of Snowbank lake, but this locality was not visited by the party.

In the Rainy lake district the party observed the relations of the several formations along one line of section at the east end of Shoal lake and at a number of other localities. The party is satisfied that along the line of section most closely studied the relations are clear and distinct. The Couchiching schists form the highest formation. These are a series of micaceous schists graduating downward into green hornblendic and chloritic schists, here mapped by Lawson as Keewatin, which pass into a conglomerate known as the Shoal lake conglomerate. This conglomerate lies upon an area of green schists and granites known as the Bad Vermilion granites. It holds numerous large well-rolled fragments of the underlying rocks, and forms the base of a sedimentary series. It is certain that in this line of section the Couchiching is stratigraphically higher than the chloritic schists and conglomerates mapped as Keewatin. On the south side of Rat Root bay there is also a great conglomerate belt, the dominant fragments of which consist of green schist and greenstone, but which also contain much granite. The party did not visit the main belts colored by Lawson as Keewatin on the Rainy lake map, constituting a large part of the northern and central parts of Rainy lake. These, however, had been visited by Van Hise in a previous year, and he regards these areas as largely similar to the green-schist areas intruded by granite at Bad Vermilion lake, where the schists and granites are the source of the pebbles and boulders of the conglomerate.

In the Lake of the Woods area one main section was made from Falcon island to Rat Portage, with various traverses to the east and west of the line of section. The section was not altogether continuous, but a number of representatives of each formation mapped by Lawson were visited. We found Lawson's descriptions to be substantially correct. We were unable to find any belts of undoubted sedimentary slate of considerable magnitude. At one or two localities, subordinate belts of slate which appeared to be ordinary sediment, and one belt of black slate which is certainly sediment, are found. In short, the materials which we could recognize as water-deposited sediments are small in volume. Many of the slaty phases of rocks seemed to be no more than the metamorphosed ellipsoidal greenstones and tuffs, but some of them may be altered felsite. However, we do not assert that larger areas may not be sedimentary in the sense of being deposited under water. Aside from the belts mapped as slate, there are great areas of what Lawson calls agglomerate. These belts, mapped as agglomerates, seem to us to be largely tuff deposits, but also include extensive areas of ellipsoidal greenstones. At a number of places, associated and interstratified with the slaty phases are narrow bands of ferruginous and siliceous dolomite. For the most part the bands are less than a foot in thickness, and no band was seen as wide as three feet, but the aggregate thickness of a number of bands at one locality would amount to several feet.

We could discover no structural breaks between the above formations of the Lake of the Woods. The various classes of materials—slates, agglomerate and ellipsoidal greenstones—all seem to belong together. In short, these rocks in the Lake of the Woods seem to us to constitute one series which is very largely igneous

or volcanic in origin, but does, as above mentioned, contain some sediments. This series in the Lake of the Woods area is the one for which the term "Keewatin" was first proposed for the greenstone series, Lawson giving as one reason for proposing this name the statement that there is no evidence that these rocks are equivalent with the rocks of Lake Huron described by Logan and Murray as Huronian.

The ellipsoidal greenstone-agglomerate-slate series is cut in a most intricate way by granite and granitoid gneiss, which constitute much of Falcon island at the southern part of the Lake of the Woods and a great area north of the Lake of the Woods. These relations between the granite and Keewatin were seen on the northwest part of Falcon island and on a small island adjacent. They were also seen north of Rat Portage. At the latter place the rocks adjacent to the granite are banded hornblende and micaceous schists, very similar to the banded rocks of Light House point, at Marquette. At Hebe falls the granite and Keewatin series are seen to be in actual contact, the Keewatin being apparently intruded by the granites, although the relations have often been interpreted as conformable gradations. Going north along the Winnipeg river, the relations between the two series become perfectly clear. Great blocks of the Keewatin are included in the granite, the masses varying from those of small size to others of enormous bulk. Also the two have intricate relations, which have perhaps been best described as *lit par lit* injection. In short, the relations are those so well described by Lawson for this area.

In the Thunder Bay district we visited especially the areas about Loon lake and Port Arthur. In the Loon lake area the succession is as follows: The top series is the Keweenawan, here consisting of sandstone above and conglomerate below, with interbedded basic igneous flows or sills. Below the Keweenawan is the Animikie. The contact between the Keweenawan and the Animikie was seen at two places. At one of these there is an appearance of conformity, but at the other the eroded edges of the Animikie iron-bearing formation are traversed by the Keweenawan beds. At one contact the base of the Keweenawan rests on the Animikie slate, interstratified with the iron formation, and at the other on one of the members of the iron-bearing formation. At both localities the conglomerate at the base of the Keweenawan bears detritus from the underlying series, including both the slate and the iron-bearing formations of the Animikie. The Animikie succession which we saw near Loon lake includes two phases of the iron-bearing formation with an interstratified belt of slate. The Animikie here has in general rather flat dips, although locally they become somewhat steeper.

Near Port Arthur the higher slate member of the Animikie was visited by a portion of the party, and on previous occasions had been visited by the other members. This is the formation which is agreed by all to rest upon the Animikie iron formation. It is notable as containing the intrusive sills called by Lawson the Logan sills.

At one place near Loon lake a test pit has been sunk to the bottom of the Animikie, and here at the base of the formation is a conglomerate bearing fragments of the next underlying series—a graywacké slate. This graywacké slate covers a large area, shows cleavage at a high angle, and is evidently an important formation in the district.

The party has no doubt that there is considerable unconformity between the Keweenawan and the Animikie, and a very important unconformity between the Animikie and the graywacké slates.

A portion of the party went north from Port Arthur to see the green-schist and granite series. This was found, but seen only in small volume at the particular area visited. At other times several members of the party have visited larger areas of this green-schist and granite complex north and northwest of Port Arthur in Gorham. Conmee, and other townships, and in the green schists they found an iron-bearing formation analogous in character to the Soudan formation of the Vermilion district. The granites are intrusive in the greenstones.

At no place were the relations between the graywacké slate series below the Animikie and the green-schist granite complex observed.

In the original Huronian area—i. e., the area described by Logan and Murray as extending from near Sault Ste. Marie along the north shore of Lake Huron to Thessalon and northward—we examined a number of crucial localities. At the first of these, about five miles from Sault Ste. Marie, near Root river, we studied the relations of the conglomerate, mapped as lower slate conglomerate by Logan, with the granite. The conglomerate is in a vertical position. We found the upper horizon of the conglomerate near the road to be of moderate coarseness, and to contain many fragments of green schist, greenstone and granite. The granite fragments increase in prominence and size toward the north, and at the north end of the exposure we have a great granite conglomerate. After an interval of a few paces we found to the north a red granite similar to many of the fragments of the conglomerate. The party has no doubt that the conglomerate rests unconformably upon the granite. This conglomerate, while mapped by Logan as lower slate conglomerate, appears to be above a limestone next to be mentioned, and has been connected by Van Hise and Leith with rocks like the red quartzite belonging above the limestone, and they believe it to be the upper slate conglomerate rather than the lower slate conglomerate, although the overlapping recent lake deposits prevent the connection by actual areal tracing. A short distance east of the point where the conglomerate is next to the granite and north of the great mass of the conglomerate is a belt of limestone which continues east for perhaps half a mile. North of this limestone is conglomerate, and still to the north, granite. This northern conglomerate is very similar to the conglomerate south of the limestone, and two interpretations are possible as to its position: it may be regarded as the lower slate conglomerate under the limestone or it may be regarded as an equivalent to the conglomerate south of the limestone, being repeated by an anticline or possibly a fault. The limestone has a steep dip to the north, and, accepting either alternative, it must be regarded as overturned.

We next visited the abandoned limestone quarry north of Garden river station. Here we found the conglomerate, marked by Logan as the upper slate conglomerate within a few paces of the limestone. This conglomerate is in all respects similar to the average of the conglomerates before mentioned, except that it contains very numerous limestone fragments. The party has no doubt that the limestone formation was laid down, and that a considerable erosion interval occurred before the deposition of the conglomerate upon the limestone. The slate-conglomerate belt north of the limestone was examined, and while it was not found in contact with the limestone, it was seen to increase in coarseness as the limestone is approached, and across the little ravine which separates the conglomerate from the limestone it was found to contain numerous limestone fragments. We therefore conclude that the rock on each side of the limestone is the upper slate conglomerate, the structure being anticlinal, possibly with faulting. This conclusion suggests that the same relation obtains at the Root river locality above described.

On the limestone point on the east side of Echo lake we found the following ascending succession, with monoclinal dip to the southeast: (1) white or gray quartzite, grading through graywacké into (2) a thin belt of conglomerate not exceeding twenty feet in thickness and containing numerous granite fragments. Above the conglomerate is (3) limestone in considerable thickness. and over this (4) the upper slate conglomerate. This last is a thick formation. The upper conglomerate is very coarse near the limestone, and becomes finer in passing away from the limestone along the lake shore. Like the conglomerate near Garden river, it bears very numerous limestone fragments, the evidence of which is beautifully seen at the lake shore, where the water has dissolved many of them completely and others in part. The ledge thus presents a deeply pitted surface, many of the pits being several inches in depth.

On the west side of Echo lake we ascended the prominent bluff next north of the west limestone point, and here found the formation nearly horizontal, but dipping slightly into the hill. The quartzite in this position composes the greater part of the bluff. A short distance from the top we found the quartzite grading upward into a graywacké-like rock, and this into a conglomerate which contains granite and green-schist fragments; indeed, it is typical slate conglomerate. This conglomerate is only a few feet in thickness, and above it appears a siliceous limestone, and above this, normal limestone like that of Garden river and the east side of Echo lake. The total thickness of the limestone here seen was probably not more than fifty feet, and of the conglomerate below, not more than thirty feet. The lower five hundred feet or more of the bluff is the white quartzite.

The other bluffs on the west side of the lake were not visited by the party, but Leith, Seaman, and Van Hise have examined each of these bluffs, and found the succession above given to obtain upon each prominent bluff, with the exception that on the next bluff to the north the limestone is wanting, so far as observed. The limestone is also in greater force on some of the other bluffs, but is always subordinate in thickness to the quartzite. It thus appears that the great formation on the west side of Echo lake is the quartzite; that the limestone above appears, not as a single belt, but as a number of synclinal patches often capping the hills; and that the conglomerate showing both north and south of the limestone is a very thin foundation between the quartzite and the limestone, and is, therefore, the lower slate conglomerate.

Our observations from Root river to Echo lake convince us that there is a considerable structural break in the Huronian. The upper series includes the following formations of Logan, viz.: white quartzite, chert, and limestone, yellow chert and limestone, white quartzite, red jasper conglomerate, red quartzite, and upper slate conglomerate. The lower series includes the lower limestone of Logan and the lower slate conglomerate, white quartzite, and gray quartzite. North of Thessalon the two series are represented by Logan and Murray as being separated by a fault. Here the distribution may be explained by the unconformity mentioned, but it is also entirely possible that the relations are due to faulting or to both unconformity and faulting.

Four miles east of Thessalon on several islands off the coast is a great conglomerate, mapped by Logan and Murray as a gray quartzite. This conglomerate was found to rest unconformably upon the granite, the actual contact being observed upon one island opposite the northwest quarter of section 12 of the township of Thessalon. The fragments in the conglomerate are well rounded and are largely granite, but there are numerous pebbles and boulders of greenstone and green schist. On several islands adjacent to the conglomerate the massive granite includes many fragments of greenstone and green schist, showing the granite to be intrusive into a greenstone formation. Thus in the complex against which the conglomerate rests we have a source both for the granite and greenstone pebbles and boulders. To the northwest the conglomerate grades up by the interstratification into a quartzite. About a quarter of a mile west of the conglomerate, near the north end of a point, the quartzite is found to become a fine conglomerate, and to rest against greenstone which is cut by a large granite dike. The greenstone shows ellipsoidal parting. The granite dike strikes toward the conglomerate and the quartzite, but it dies out into a depression showing no rock, which continues to the quartzite some fifty or sixty feet distant. The quartzite and conglomerate strike directly across this depression, showing continuous exposures, and are not cut by granite. The relations here are believed by certain members of the party to show clearly that the quartzite and conglomerate rest unconformably upon the greenstone, but other members felt that this conclusion is not certain. The conglomerate and gray quartzite are cut by greenstone dikes. Similar rocks also cut the Thessalon series referred to below.

The rocks called green chloritic schist by Logan (3c) will here be called the Thessalon series. This series consists of ellipsoidal greenstones, amygdaloids, agglomerates, and massive greenstones. No undoubted sediments were observed in the series. The relations of the Thessalon series to the granite were observed southeast of Little Rapids, and it was found that the granite cuts the greenstone series in an intricate fashion. The belt of gray quartzite, mapped as extending inland for a number of miles between the Thessalon series and the granite, was found to be absent at this locality. Two or three miles east of Thessalon, felsite and granite in considerable masses were found to intrude the Thessalon series. At one place several felsite or granite dikes were observed to cut both the agglomerates and ellipsoidal greenstones. From the relations observed, the party had no doubt that the conglomerate islands east of Thessalon belong unconformably upon the granite, and they think it probable (Van Hise would say highly probable) that the quartzite and conglomerate rest unconformably upon the Thessalon series, mapped as green chloritic slate by Logan and Murray. It is regarded as probable that the white quartzite below the lower slate conglomerate northwest of the Thessalon series which is adjacent, and is shown by its dip to rest upon the Thessalon series, is separated from that series by an unconformity, but no direct evidence of such relation was observed.

The Thessalon series should be excluded from the Huronian if, as believed, the unconformity just mentioned exists. If this series be excluded, the Huronian of Lake Huron consists of two series, an Upper Huronian and a Lower Huronian. The Upper Huronian extends from the top of the series, as given by Logan and Murray, downward to and including the upper slate conglomerate; and the Lower Huronian extends from the main limestone formation to the gray quartzite, including its basal conglomerates. In the area mapped by Logan on the north shore of lake Huron the Laurentian consists of granite and gneissoid granite, with subordinate inclusions of greenstone.

We do not feel that our examination of the Lake Superior region was sufficiently detailed to warrant an attempt at correlation of the individual formations of the various districts. There are, however, certain general points which seem to be reasonably clear, and about which there is no difference of opinion between us. These are as follows:

There is an important structural break at the base of the Keweenawan. The term "Keweenawan" should include substantially all of the areas which have been thus mapped, or mapped as Nipigon, by the Canadian and United States Surveys, and the State Surveys of Michigan, Minnesota and Wisconsin.

Below the Keweenawan is the Huronian system, which in our opinion should include the following series; In the Marquette district, the Huronian should include the Upper and Lower Marquette series, as defined in the monographs of the United States Geological Survey, or the Upper, Middle, and Lower Marquette series, as given in the previous paragraphs. In the Penokee-Gogebic district, the Huronian should include the series which have been called the Penokee-Gogebic series proper, and the limestone and quartzite which have local development, and which we visited east of the Presque Isle river. In the Mesabi district, the Huronian should include the Mesabi series proper, and the slate-graywacké-conglomerate series, unconformably below the Mesabi series. In the Vermilion district, the Huronian should include the Knife slates and the Ogishke conglomerates. In the Rainy lake district, the Huronian should include that part of the Couchiching of the south part of Rainy lake which is limited below by basal conglomerate as shown at Shoal lake. In the Thunder Bay district, the Huronian should include the Animikie and the graywacké series in the Loon lake area. In the original Huronian area, the Huronian should include the area mapped by Logan and Murray as Huronian, except that the Thessalon greenstones should probably be excluded.

Unconformably below the Huronian is the Keewatin. The Keewatin includes the rocks so defined for the Lake of the Woods area and their equivalents. We

believe the Kitchi and Mona schists of the Marquette district (Mareniscan) of the Penokee-Gogebic district, the greenstone series of the Mesabi district, the Ely greenstones and Soudan formation of the Vermilion district, the part of the area mapped as Keewatin by Lawson in the Rainy lake district not belongong structurally with the Couchiching, and probably the Thessalon grenstone series on the north shore of Lake Huron, to be equivalent to the Keewatin of the Lake of the Woods, and, so far as this is true, they should be called Keewatin.

For the granites and gneissoid granites which antedate, or protrude through, the Keewatin, and which are pre-Huronian, the term "Laurentian" is adopted. In certain cases this term may also be employed, preferably with an explanatory phrase, for associated granites of large extent which cut the Huronian, or whose relations to the Huronian cannot be determined.

The following succession and nomenclature are recognized and adopted:

CAMBRIAN—Upper sandstones, etc., of lake Superior.

Unconformity

PRE-CAMBRIAN

Keweenawan (Nipigon)[1]

Unconformity

Huronian
- Upper (Animikie)
  - *Unconformity*
- Middle
  - *Unconformity*
- Lower

Unconformity

Keewatin

Eruptive contact

Laurentian

Alphabetically signed by the committee as follows:

FRANK D. ADAMS,
ROBERT BELL,
A. C. LANE,
C. K. LEITH,
W. G. MILLER,
CHARLES R. VAN HISE,
Special Committee for the Lake Superior Region.

[1]Dr. Lane dissents as to the position of the Keweenawan as follows:
"The use of pre-Cambrian above does not imply unanimity in the committee with regard to the pre-Cambrian correlation of the Keweenawan—a topic the committee as such did not investigate."

IRON RANGES OF MICHIPICOTEN WEST

BY J M BELL

The Michipicoten Huronian Area

Since the first discovery of iron ores in the Lake Superior region, it has been a matter of very general observation that these ores occur within the limits of belts of rocks of certain definite characteristics. These belts of iron-bearing rocks are generally known as ranges. The word "range" does not imply a mountain chain or ridge; but is used in a loose sense, merely to indicate that the iron-bearing rocks trend in a general linear direction, and that the area occupied by them at the surface is much greater in longitudinal section than in cross-section. Often, however, the iron-bearing rocks occupy a prominent position in the landscape in which they occur, and are relatively mountainous as compared with the rocks of generally faint relief with which they are associated. Hence, in a way, even in the correct sense the word "range" is not inappropriate.

On the United States side of Lake Superior there are several prominent belts of iron-bearing rocks. Important among them are the Marquette Range, the Menominee Range, the Penokee-Gogebic Range, the Mesabi Range and finally the Vermilion Range. On all of these iron ranges monographs have been written which have been of great value to the miners and prospectors of the country. Each range has produced, and is still, annually, producing immense quantities of iron ore.

On the Canadian side of Lake Superior we, also, have belts of iron-bearing rocks, though these have as yet not proved so important as on the other side of the line. Among these ranges may be mentioned the Mattawin, the Atikokan, the Animikie, the Nipigon, the Michipicoten, the Batchawana, the Hutton and the Temagami. Though these various ranges have been examined in a more or less cursory manner, very little systematic work has up to the present been undertaken. Only one of these ranges, the Michipicoten, is at present an iron producer, but there is apparently no reason why with further exploration several or all of them may not be found to contain ore-bodies of value.

It was with the especial object of making a careful examination of the Michipicoten iron range that the writer was instructed by the Director of the Bureau of Mines to make a geological survey of the Michipicoten Huronian area. The area lies on the north shore of Lake Superior, encircling Michipicoten bay, and is for the most part included within the boundaries of the Michipicoten Mining Division set apart by the Ontario Government in 1897, but some of the Huronian rocks lie beyond the limits of the division. The Huronian rocks have a surface area of some 1,700 square miles, and are contained between N. lat. 47° 30' and N. lat 48° 30', and longitude 84° west and longitude 86° west. The area may be divided into four divisions. The south section includes all Huronian rocks from the point some four or five miles north of Point Gargantua, where they first appear on the Lake Superior shore, to the Michipicoten river, and as far east as the mouth of its tributary, the Sequamka. All bands of iron-bearing rock within this stretch make up the south Michipicoten Iron Range. The east section of the Huronian area extends eastward from the Magpie river to the Michipicoten and Sequamka, and contains the east Michipicoten Iron Range.

With the east Michipicoten Range belong the few small broken bands of iron-bearing rocks occurring west of the Magpie river near Michipicoten Harbor. The northern Michipicoten Huronian, enclosed between two areas of granite, lies between the Magpie river and the western branch of the Pucaswa river. The iron range which it contains is practically a continuation of the eastern range. The western Huronian area, which is separated from the other three by granitic rocks, intrusive in the Huronian, includes three small patches of Huronian rocks, divided by later granite. It lies between Otter Head and Bear river, on the Lake Superior shore, and extends but a short distance north of lake Michi-Biju. Within these is the western belt of iron-bearing rocks.

The eastern Michipicoten Range is much the best known of the iron-bearing belts because it has been carefully studied by Professor Coleman and Professor Willmott, and a report published thereon.[1] This part of the range contains also the working mine—the Helen; the Josephine prospect, and the old mine on Gros Cap worked nearly thirty-five years ago. However, much investigation has to be carried out in parts of this stretch of country before the geological examinations can be said to be complete. The southern Michipicoten Huronian has been examined only in a very hurried way, and no attempt has been made to connect the various bands, known to occur at lake Majinimungshing, cape Choyyé, lake Anjigomi, and elsewhere. On the northern Iron Range the valuable prospects of the Scott, the Frances, and Iron Lake are located, and the belt on which they occur was examined in somewhat slight detail by the writer with Mr. Albert Scott while in the employ of the Algoma Commercial Company, Ltd., in 1902. Dr. Robert Bell also made some investigations on the same belt for the Dominion Geological Survey in 1900.[2] Up to the past summer no connected survey had ever been made of the western range.

During the summer of 1904, the writer, with the assistance of Mr. H. W. Evans of Toronto, carried on geological explorations on both the western and northern ranges, and completed a fair geological survey of the region as far east as the Magpie river. Besides the writer and his assistant the party consisted of a cook and two Indian voyageurs. The party, though small, was a good one, and adequate for the work in hand. Our work was almost entirely by land. While investigating the western range, trips were made inland at intervals of a mile or a little more, crossing the strike of the rocks from the Lake Superior shore to the edge of the granite on the north, and south or north from lake Michi-Biju to the edge of the granite. In the same way traverses were made at short intervals across the northern range from granite to granite. Thus the various bands of iron-bearing rocks which do not appear on the principal watercourses, were discovered and their trend traced across country. In a country broken by rough hills, often separated by swampy valleys, and covered with a dense forest growth, these trips across country day after day were often very arduous, but the work was interesting, and for the most of the summer we were favored with exceptionally fine weather. Generally the trips made inland from the lakes and rivers lasted but one day, going in the morning and returning in the afternoon, often by a new path in order to examine fresh country, but sometimes, as in investigating the country west from Iron lake, it was necessary to tramp for three or four days through the woods without returning to the main camp. When iron-bearing rocks were found as a rule they were of prominent outcrop and easily traceable. When they disappeared beneath muskegs or sand plains, we were sometimes able to trace their continuation by magnetic work, in this following the plan outlined by Professor H. L. Smyth in his pamphlet published by the American Institute of Mining Engineers.[3]

1 "The Michipicoton Iron Region," Bur. Mines, 11th Rep., pp. 152-185.
2 See Ann. Rep. Can. Geol. Sur., 1900, pp. 109-121A. 3 Trans. A.I.M.E., Vol. XXVI, 1896, pp. 640-709.

BIBLIOGRAPHY OF THE REGION

For the convenience of those who may be interested in the subject, I give the following list of the literature already published on the Michipicoten Huronian area or on the region adjoining:

Report of the Geological Survey of Canada for 1846-1847, in which Logan describes the conglomerate at the mouth of the Doré river and the sandstones at Cap Choyyon and Cape Gargantua (p. 31). In it, also, Murray has some notes on the Michipicoten river.

Lake Superior, its Physical Character, Vegetation and Animals; Louis Agassiz, 1850.

Report of the Geological Survey of Canada, 1863, in which the Huronian slates at the Doré river are described (p. 52), sandstones of Cape Gargantua considered (p. 82), and the native copper of Cape Gargantua and a deposit of chalcopyrite on Michipicoten bay mentioned (p. 703).

Report of the Geological Survey of Canada, 1866, in which Macfarlane describes the Lake Superior rocks and the occurrence of hematite at Little Gros Cap (p. 130).

Report of the Geological Survey of Canada, 1870-1871, in which Robert Bell describes the Pic and White rivers, and the geology of the surrounding country.

Report of the Geological Survey of Canada, 1875-1876. In this report Robert Bell gives some notes on the Michipicoten river (pp. 331-335).

Report of the Geological Survey of Canada, 1876-1877, in which Robert Bell gives a description of the rocks of the Lake Superior shore from Gros Cap to Cape Gargantua (p. 218).

Report of the Geological Survey of Canada, 1880-1882. Here Dr. Bell gives an account of the rocks of the Michipicoten river and of Dog lake, accompanied by a geological map.

American Geologist, vol. xx., p. 126, etc. An article by Taylor in which he considers Dog lake not an outlet of Lake Superior.

Minnesota Geological and Natural History Survey, vol. xx. Notes by Lawson on the beaches at Dog river.

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Ontario Bureau of Mines Report, 1897, vol. vii., part 2, pp. 184-200. Michipicoten Mining Division, by A. B. Willmott, 1898, in which the Magpie and Michipicoten rivers are described, accompanied by a geological map.

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"The Michipicoten Huronian Area," A. B. Willmott. The "American Geologist," vol. xxviii., July, 1901, p. 14, etc., in which the eruptive relation of the granites is pointed out and a map given showing the northern iron range.

Report of the Ontario Bureau of Mines, vol. xi., 1902, pp. 152-185. "The Michipicoten Iron Range," by A. P. Coleman and A. B. Willmott. The writers give here a detailed description of the eastern Michipicoten Iron Range.

Journal of the Canadian Mining Institute, vol. vii. "Exploration of the Ontario Iron Ranges," by A. B. Willmott, in which Willmott considers the possibilities or some of the prospects in the Michipicoten Iron Range.

"The Nomenclature of the Lake Superior Formations," by A. B. Willmott. Journal of Geology, vol. ix. (1902). No. 1, p. 67, etc.

Report of Ontario Bureau of Mines, vol. xi., 1902, pp. 70-75, by D. G. Boyd, Inspector. A statistical report of the development in Michipicoten.

PHYSIOGRAPHY OF THE AREA

As has been mentioned, our especial work during the summer of 1904 was an examination of all iron-bearing rocks occurring west of the Magpie river. However, to elucidate, if possible. the problems relating to these rocks, the general geology of the region was studied somewhat in detail and the physiography rather superficially examined.

The topography of the region is one of considerable variety, and that characteristic of the more rugged and less levelled phase of the old Laurentian peneplain of central Canada. Along the shore of Lake Superior high, hummocky, ridge-like hills rise often abruptly from the water's edge. This rugged shore line is interrupted at intervals by broad sand beaches, which break the monotony of the precipitous cliffs. The highest hills, and those of greatest relief above the surrounding country, lie within twelve miles of the Lake Superior shore. Northward, the uneven broken character of the country decreases rather than increases, hills rising to considerable heights above the general level of the country are fewer, and their relief not so great as farther south. Moreover, whereas there is a somewhat rapid rise from the Lake Superior shore of the general level of the country for several miles inland, northward the rise towards the height of land, between the waters of the St. Lawrence and those of Hudson Bay, is so slight as to be scarcely perceptible on the various rivers.

A Region of Hills and Valleys

In general the surface of the country, with its broken ridges, alternating with narrow linear valleys, may be spoken of as hilly. It stands in marked contrast to the surface of the Laurentian plateau north of the Height of Land, which is practically level and devoid of relief. Some distance north from the lake Superior shore the soft Huronian schists are conspicuous physiographically as forming relatively low lands compared with the highlands occupied by the resistant post-Huronian granitic rocks. This difference is not so apparent on the Lake Superior shore, but it is nevertheless evident in places. In going north from Ellen lake, I was particularly struck with this marked physiographic difference between the schists and the granitic rocks. North from Ellen lake for about three miles the rocks consist of granite. Near the northern limit of these rocks the hills abruptly descend to a broad valley four or five miles wide, beyond which the hills rapidly rise again at the border of the northern granitic rocks. The valley contains the northern Michipicoten Huronian synclinonium with its associated iron range.

The highest hills in the Michipicoten area have an altitude of from ten to twelve hundred feet above sea level, and a view from the summit of any of these shows that almost all the other hills rise to the same general height. This uniform altitude indicates, apparently, the existence of a former peneplain, or base-level of erosion, which has been elevated since its formation and is at present undergoing another cycle and being reduced to a second, or possibly third, base-level of erosion by the comparatively rapid action of streams, frost, heat and other atmospheric agencies.

Tip-Top mountain, which Dr. Coleman considers possibly the highest point in the Province of Ontario, lies almost seven miles west of the lake Superior shore and about ten miles north of Otter Head. Its height, as given by Dr. Coleman, is 1,525 feet above lake Superior, or 2,125 feet above sea level.[4] High ridges of hills occur north of Ganley's Harbor, north of Lost lake towards the Pucaswa river, along the eastern branch of the Pucaswa, in the vicinity of Bear Mountain and at various other points.

Within the limits of the northern Michipicoten Huronian area proper the highest hills, which stand out very definitely in this generally low-lying region, consist of eruptive rocks entirely, or at least have a core composed of these rocks, or otherwise

[4] Eighth Rep. Bur. Mines, 1899, p. 142.

they are composed of the resistant quartzose rocks of the iron-bearing formation. The most prominent elevation in this northern part of the Huronian area is that of the Kabenung hills a low range which follows along the northern shore of Kabenung lake for a little over a mile. These hills have probably an altitude above Lake Superior of about 1,200 feet, but the local relief very little exceeds 350 feet, if so great. Heart mountain on the shore of Heart lake, about 250 feet above the surrounding country, and mount Raymond about 300 feet above the waters of Paint lake, near which it is situated, are other conspicuous points on the landscape. These prominent elevations with many others may be spoken of as monadnocks, or hills still standing above the

Fishing village, Michipicoten island.

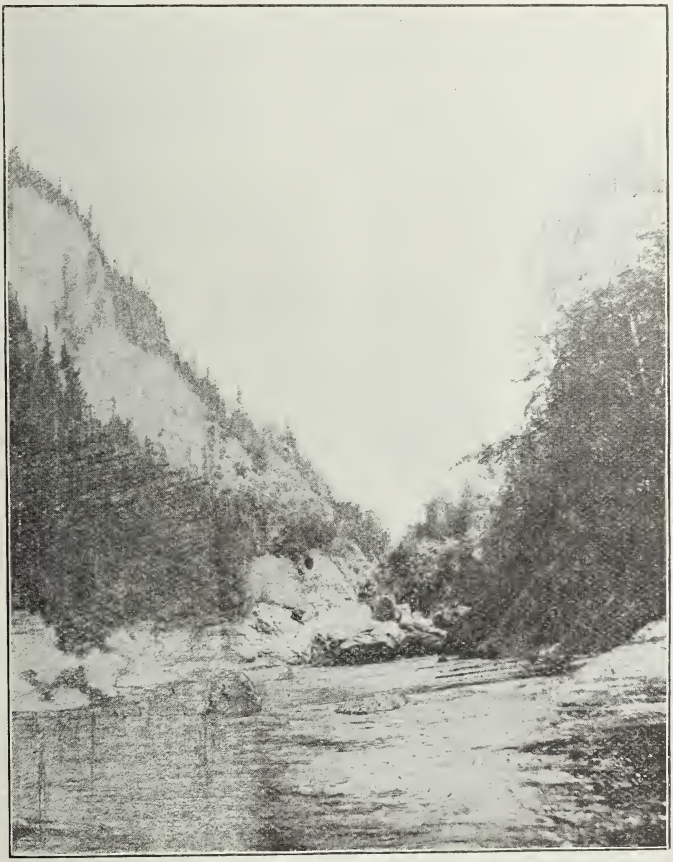
general level, which have been able to resist the long-continued subaerial erosion. In many parts of the country broad lacustrine sandplains, or fairly extensive swamps and muskegs, intervene between the stretches of hilly country and break the usual uneven character of the region.

Rivers of the District

The area is drained by numerous streams and rivulets which thread their way from lake to lake, sometimes almost stagnant for a mile or more, again wild foaming torrents, with rapids over beds of boulders, or waterfalls over cliffs. The largest streams, in the western and northern Huronian areas, are the Pucaswa river and the Dog river, which enter Lake Superior, and the Magpie river, which flows into the Michipicoten river. Other considerable streams flowing into Lake Superior are the Julia river, the Pipe river, the Floating Heart river, the Eagle river, Fall creek, the Bear river, the Little Bear river, and the Doré river. Like all glaciated countries, the region is thickly dotted with lakes varying in size from ponds only a few yards across, up to sheets of water five miles or more in length. These natural reservoirs maintain a fairly uniform flow of water in the various streams, throughout the year, though of course the effects of dry weather or increased rainfall are decidedly observable.

THE PUCASWA

The Pucaswa river was descended[5] by Dr. Coleman from a point about 25 miles above its mouth to Lake Superior in 1898. He describes it as being throughout this distance a particularly difficult stream to navigate, being merely a succession of shallow rapids broken by very short stretches of navigable water. Unlike most of the rivers which enter Lake Superior, there are no lake expansions along its course, at least for 25 miles from its mouth, though there may be, farther towards its source. From a point one-half mile above its mouth the river descends some 55 feet in a distance of less than a quarter of a mile in a roaring cataract, hemmed in, particularly on the north side, by walls of schist, which rise two to three hundred feet above the river bottom. The bed of the stream is filled with immense angular boulders which increase the broken character of the water. Dr. Coleman describes this fall of 55 feet as being the highest fall in the course of the river.

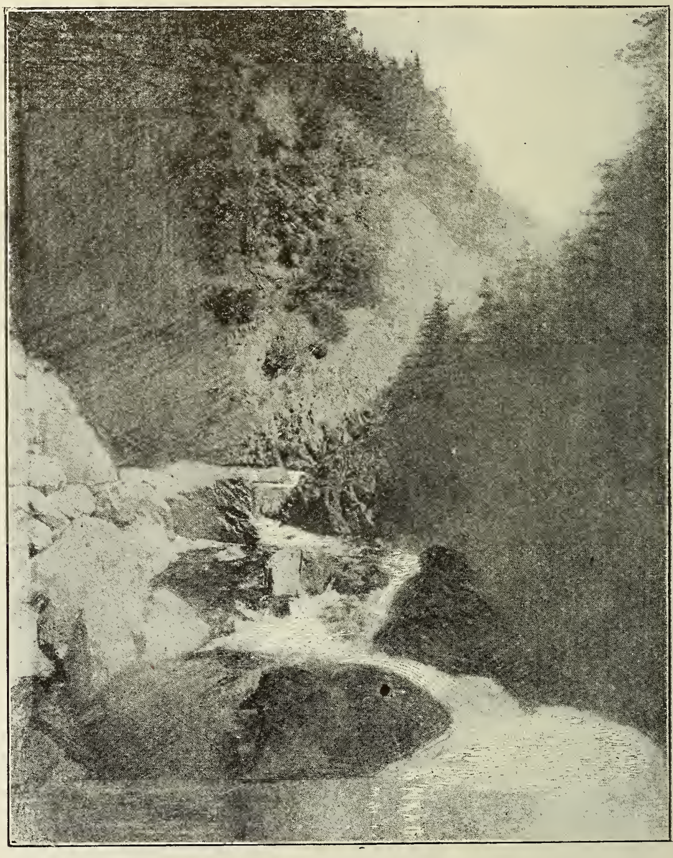


Gorge on the Pucaswa river, near its mouth.

Some five miles above its mouth the main Pucaswa river is joined by the eastern branch, coming from the northeast. This stream is apparently rather more than half the size of the main river. The united stream below the confluence has a width of about fifty yards. The eastern branch rises in a number of small lakes which lie south of Fox lake, near Pokay lake, and about eight miles north of Iron lake. The eastern branch has a length of about thirty miles, and like the main river, is nothing but a

5 Report of Ontario Bureau of Mines 1899, Part II.

succession of shallow rapids and low falls joined by short stretches of more slowly moving water. Neither the main Pucaswa nor its eastern branch is ever now used as a route through the country by the Indians, though it is said that they were navigated in summer some twenty years ago or more by a family who bore the name of Pucaswa from the stream on which they lived, and who were all drowned in crossing to Michipicoten island early in spring. There is a fairly good portage-trail on the left bank of the stream, past the falls near Lake Superior, but this is apparently the only sign of the former use of the river.



Gorge on Pucaswa river, near mouth.

A small stream some ten miles in length, which enters near or at Otter Cove, rises near the Pucaswa river, and is still used by the Indians in entering the country. The stream joins together a number of small expansions, the portages between which are short, and there is only one long carry of about two miles from Otter Cove to the first lakelet.

Some two and a half miles southeast of the mouth of the Pucaswa, the Julia river enters Lake Superior. It is a small rapid stream, only six or seven miles in length, which rises in some small lakes and ponds to the northeast of its mouth. The Pipe river, which enters Lake Superior about seven miles southeast of the Julia river, has a length of about six miles, and drains a number of lakes one-half mile or more in length. These lakes form part of the canoe route, from Red Sucker harbor to the David lakes, near the Pucaswa river.

Floating Heart river, which flows into Lake Superior about a mile and a half east of Ganley's harbor, is the largest stream between the Dog river and the Pucaswa. It drains Floating Heart lake, Lost lake, and the lakes lying to the southwest of lake Michi-Biju. Some of these lakes are on the route between the mouth of the Ghost river, via Little Trout lake, to lake Michi-Biju.

Eagle river flows into Lake Superior just west of the high cliffs known as "Les Equerres,"[6] and about eight miles west of the mouth of the Dog. The river drains Cameron lake and other lakes south of lake Michi-Biju, and is not navigable. About a mile above its mouth are falls of great beauty, which occur in a succession of three jumps close together, each of about thirty feet. Fall brook is a small rapid stream, flowing into Lake Superior about three miles west of the Dog river.

DOG RIVER

The Dog river, which has an average width of rather less than seventy-five yards near its mouth, is navigable from its headwaters to Lake Superior, though broken by considerable stretches of rapids. It may be said to be formed by the union of several small streams which enter Obatonga lake, an irregular, marshy sheet of water lying some twenty-seven miles north of Lake Superior. Leaving Obatonga lake, after a course of about one-half mile, on which there is a rapid which has to be portaged, the river enters Knife lake. This lake, which is some three miles long, the river leaves at its southern end, and after a course of less than a mile, enters Heart lake. There are two portages, the most northern of which is only a lift between Knife lake and lake George. Heart lake is a narrow sheet of water about a mile and a half long. From its outlet to Lake Superior the Dog river is broken by many rapids and falls. These are short and unimportant, and do not seriously impede navigation as far as the mouth of the stream from Ekinu lake, but south from this point their frequency and length form a great impediment, and render the route by Ekinu lake, Mud lake and lake Michi-Biju the preferable one to Lake Superior.

The most important tributary of the Dog river, from the west, is Iron creek, which enters the river about three miles below Heart lake, and drains Iron lake, Little Beaver lake, Sigami lake, Nichols lake, and others. Joining the Dog river from the east there are three principal tributaries, the Crayfish river, Paint creek and Mountain river. The Crayfish river enters the Dog river between Knife and Heart lakes, and drains the important chain of lakes which includes Kabenung lake, Lac Poisson Gris, and Muskrat lake. Paint creek flows into the Dog river, some two miles below Heart lake. It is navigable for three miles above its mouth as far as the Frances mine, and drains Paint lake, Sage lake, Skunk lake, and other lakes lying to the south of Sage lake. The Mountain river flows into the Dog about five miles above its mouth. It is a rapid stream, seldom used by the Indians, and drains Jimmy Kash and adjoining lakes.

The Mountain Ash river, the Bear river, and the Little Bear river, are three small and unimportant streams which drain the rocky interior between the Dog river and the Doré river. The Doré river is formed by the union of a number of small streams which rise in lakes south of Muskrat lake and from eighteen to twenty miles north of Lake Superior. Some three miles from Lake Superior is Doré lake, an almost round body of water about two miles from north to south. Below Doré lake a continuous succession of falls and rapids render navigation impossible. Above Doré lake for some three or four miles the travelling on the river is easy and without serious impediment. Northward, however, rapid after rapid, unrelieved by long stretches of smooth water, make it a very difficult route to Sage lake, though it is sometimes followed by the Indians, and was descended by Mr. Evans late the past autumn.

[6] Pronounced by the natives *"DesEcöres."*

THE MAGPIE RIVER

The Magpie river rises in Esnagami lake, north of the Canadian Pacific railway, and after a course of some fifty miles, it enters Michipicoten river about three-quarters of a mile from Lake Superior. Near its mouth its usual width is from fifty to eighty yards. Southward from the Chute which impedes navigation on the river at about three and a half miles south of McKinnon's bridge, the river is broken by long and almost continuous stretches of shallow rapids. These are not sufficiently large to prevent travelling by canoe, but are often difficult to pass in low water though almost obliterated in seasons of flood. During this stretch there are three falls of magnitude. One is at the mouth of the river, and has a drop of 113 feet. The second series of falls have a drop of 73 feet, and break the river some two miles above its mouth, and the third, the Steep Hill falls, with a drop of 60 feet, are about sixteen miles from the mouth. Above the Chute long stretches of smooth water, often lake-like, are broken by small and easily passed rapids as fas as the Portage falls some three miles above McKinnon's bridge. For six miles above the Portage falls the river meanders through a sand-plain and no rapids occur. Then the smooth water is broken by over two miles of rapids Kabetachewan or Long rapids. North of Long rapids extensive stretches of navigable water are interrupted by only short rapids and falls as far as the Canadian Pacific railway—a distance of about eight miles.

The Magpie river has two important tributaries from the west—Evans creek and Catfish creek. Evans creek drains the chain of lakes east of the Grand Portage between the waters of the Magpie and Dog rivers. These lakes include lake Kapinchigama, Lund lake, lake Pasho-scoota, Godon lake and Pyrrhotite lake. Catfish creek rises in a number of small lakes lying south of lake Maguire, and enters the Magpie river about ten miles above its mouth. Some three miles up its course from the Magpie is Catfish lake, an expanse of water some two miles in length. Below Catfish lake the river is a succession of shallow rapids, and is too much filled with driftwood to be navigable. It has an average width of about forty feet. Above Catfish lake for some three miles there is no serious impediment to navigation, although log jams and short rapids break its course at intervals. Higher up the river, however, rapid after rapid, all of which are shallow, render the stream a very difficult one by which to travel. It is occasionally used by the Indians in high water, and was descended by the writer during the autumn of 1904.

It will be seen from this brief account that the rivers of Michipicoten are rapid streams, all of which have a large average drop per mile. In general, however, the average descent per mile increases towards Lake Superior, and in the lower part is often so great as to preclude navigation altogether, whereas in the upper stretches lake expansion, or slack river water, render that part of the various streams quite suitable for travel. The Magpie from the Canadian Pacific railway to Lake Superior has a descent of some 550 feet, and of this quite 190 feet occurs within the last two miles and a half. Similarly the Dog river has a descent from McMaster lake (in which one of its headwater streams rises) to Lake Superior of about 780 feet, and of this 175 feet occurs within the last two miles. The main branch of the Pucaswa, according to Dr. Coleman,[7] has a descent of 575 feet from a point some 25 miles up its course to Lake Superior.

Lakes of Michipicoten

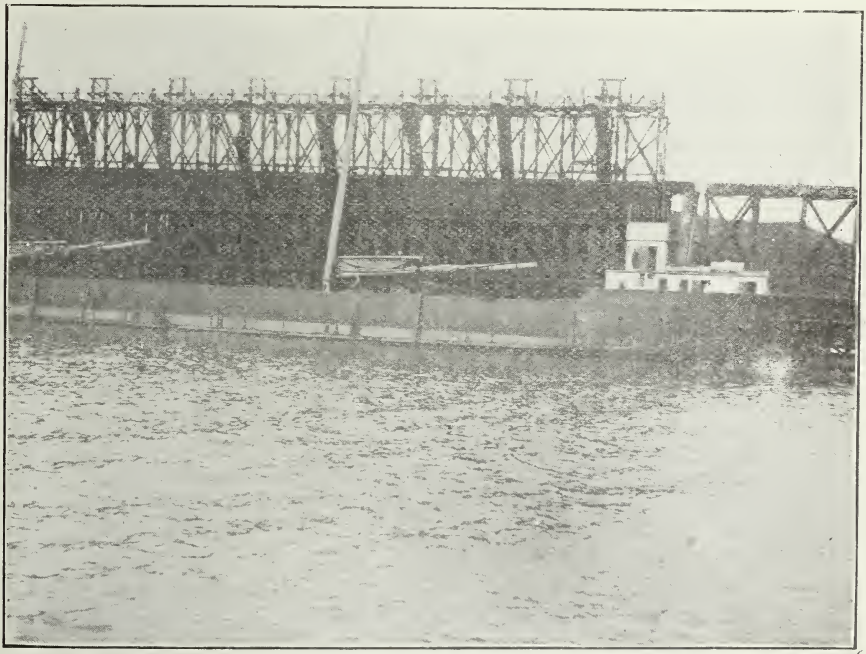
As has already been mentioned, lakes are common physical features in Michipicoten. They are of two types—those which occupy rock basins, the outlet of which is dammed by rock ledges or by moraines, and those which fill holes in the drift formerly occupied by masses of ice, left by the retreating ice sheet. Of these two classes the first is much the most important, and to it belong all the larger lakes in the region, including the river expansions. To the second class belong the numerous

[7] Eighth Rep. Bur. Mines, 1899, p. 138.

ponds, seldom exceeding one-half mile in length, which dot the few level stretches in the wooded interior of the country.

The largest lake in the Michipicoten area west of the Magpie is Kabenung lake, a sheet of water some seven miles in length, and with a maximum width of about two miles. It is of exceedingly irregular outline, like all the lakes in Michipicoten, and is divided into two parts by a narrows a few yards wide and less than one-eighth of a mile long. The surface area of its water, owing to the numerous islands which occur within it, is much smaller than most lakes of its dimensions. After Kabenung lake the lakes next in size are lake Michi-Biju, and Michi lake, which are joined to each other by a small stream about seventy-five yards long. Michi-Biju lake is some two and a quarter miles long by a mile and a quarter wide, while Michi lake is about a mile and a half long by three-quarters of a mile wide. They are both beautifully clear-watered lakes with very few islands.

Compared with the country north of the Height of Land swamps and muskegs are comparatively rare, but often the smaller lakes especially, and even some lakes of



Dock, Michipicoten.

fair size, are surrounded by wide borders of marsh. Again, the lakes in the marsh may have become quite insignificant or have disappeared altogether, and a wide area of grass-covered meadow be all that remains of a former extensive body of water. Most of the lakes are shallow, and there are few which exceed thirty or forty feet in depth. Some are so shallow, such as Mud lake, near lake Michi-Biju, and the Big Marsh, near lake Maguire, that it is almost impossible to get through them by canoe, especially when towards the close of the short season, their surface is choked with patomogetons and pond lilies which grow in the decaying product of their own decomposition

The water in most of the Michipicoten lakes is brownish in color, and not clear whitish water. There are two rather remarkable ponds on the trail from Dog river to Iron lake. These are Spring lake and Clearwater lake. They are both small, but are comparatively deep depressions in the glacial drift. The upper pond, Clearwater lake, is held in by a narrow moraine which follows its eastern border. Their water

is of remarkable transparency, and is possibly lower in temperature during the summer than that of the surrounding lakes. The lower pond, Spring lake, has a bottom composed of rounded cobbles of various sizes, coated with a whitish material, probably in great part vegetable, which enhances the bluish-white coloring of the water. The outlet of the two ponds is by Clear creek, which enters the Dog river some four miles below the mouth of Iron creek. The lakes are supposed by the Indians to be springs, and though I could find no direct evidence in favor of this hypothesis, the large size of the stream which drains them compared with the small size of the entering streamlets seems to give proof to the theory.

Effects of Glacial Action

The Michipicoten region is one of pronounced glaciation, showing on the whole greater denudation than deposition. The rocky hills exhibit the mammillated contours characteristic of regions which have been invaded by the ice sheets, and everywhere the surface of the solid rock is grooved and striated. The glacial striæ vary somewhat in direction throughout the area. On the Lake Superior shore near the Dog river, the usual trend is from S. 10° W. to S. 15° W., but towards the interior, especially in the northeastern part, the direction is more southwestward. The wide sandplains which are of frequent occurrence in Michipicoten, may represent the deposits formed by the waters of Lake Superior when it stood at a higher level, or possibly they are at least in part the sediments laid down by lakes formed in close contact with the retreating continental ice sheet. Numerous boulders scattered irregularly over hill and valley are further evidence of the work of the glaciers. Well-marked moraines of various kinds are common, and often greatly influence the drainage. Somewhat remarkable are the immense irregular masses of coarse moraine stuff which occur on the Mountain Portage between Pokay and McMaster lake, described by Dr. Robert Bell.[8] The elevated beaches marking the former level of the water, which fringe the present margin of Lake Superior, often for miles into the interior and at considerable heights above the present level of the water, have already been described by various writers.[9] Remarkable terraces occur near the lake Superior shore, extending from a point three miles east of the mouth of the Dog river to a short distance west of that stream. They can be seen to best advantage some two or three miles out in the lake. They are composed of fine gravel and sand, and are distinct and clear cut in outline. Terraces may also be observed in the lower and upper parts of the Dog river, and on the Pucaswa river.

As the Michipicoten district has only so recently been inhabited by white men, it contains few evidences of white occupation. On the western side of the Magpie there is a small settlement at Michipicoten Harbor, where the ore docks are situated, and on the eastern side of the river there are the settlements of Michipicoten River, of Wawa City, and of the Helen Mine. Formerly there were small settlements at the Frances mine and at Iron lake, to the west of the Magpie, but these are at present deserted. The line of the Algoma Central railway is at present built as far as the Josephine mine, with a spur to the Helen mine. There is a good road from Michipicoten river to Wawa City, and to the railway at Wawa station, also a road to the Grace mine, to Anjigomi lake, and to other points near Michipicoten river, built before the cessation of work on the Algoma Central railway. The old tote road to Ryerson, built at the time of the construction of the Canadian Pacific railway, was cleared out and improved by the Lake Superior Power Company in 1900, and though now practically disused, is still in pretty good repair. It has been chiefly used in winter, though there is no reason why it could not be made a good summer route. It lies on the eastern side of the Magpie as far as MacKinnon's bridge, where it crosses the river and follows close to the western border of the river for some twelve miles, when

8 Summary Report Geol. Sur. Can., 1900, p. 120.

9 Geol. Nat. Hist. Sur. Minn., 20th Annual Report. Eighth Rep. of Ontario Bureau of Mines, 1899, p. 153, etc.

it diverges and strikes across country to Ryerson on the Canadian Pacific railway. There are old winter tote roads from Michipicoten Harbor to the Frances mine, and from the Frances mine toward White River station, but these are scarcely recognizable as highways through the country in summer. The proposed extension of the Algoma Central railway crosses the Magpie a mile or two below McKinnon's bridge and follows south of the chain of lakes which stretches between the Magpie river and Dog river. It crosses the latter below Heart lake and follows to the west of that body of water and of Knife lake, northward.

In fact, save for a very small section of the country the sole means of travel through the region in summer is by the long used Indian canoe routes along the rivers or by the chains of lakes and portages; while in winter the entire area, save at the few isolated settlements, is given over to the Ojibway hunters who still roam and hunt throughout the district.

CANOE ROUTES

For the convenience of travellers who may in future visit the Michipicoten country west of the Magpie river, I shall here give a brief description of the principal routes of travel throughout the area. The route via the Magpie river from Grassett to Lake Superior,[10] the route from White River station via White and Dog rivers to Lake Superior,[11] and the route via Bremner river and Pucaswa river to Lake Superior,[11] have already been described, and it is unnecessary for me here to consider them in detail.

Lake Superior to Frances Mine

The canoe route from Lake Superior to the Frances mine leaves the shore just behind the settlement of Michipicoten Harbor. The trail leads for some two and three quarter miles over low hills, through a wide swamp and around several small ponds which may or may not be utilized, depending on the state of the water, to Doré lake. The Doré river is ascended for some three miles when a portage leaves the stream on the right bank and stretches across the low hills near Eagle mountain for about two miles to the stream which flows out of Molybdenite lake. In high water this stream may be used, but as a rule loads are carried through to the lake. Molybdenite lake is an irregular body of water a little over a mile long, which the route leaves at the north end. Nine lakes, all small, succeed Molybdenite lake. They are separated by short portages varying in length from a few hundred yards to over half a mile. From the most northern of these lakes a good trail of five miles leads to Kash lake. Kash lake, or perhaps more correctly Jimmy Kash lake, is a crooked sheet of water over three miles long. A small stream flows into its northern end from lake Isabella—a round pond about a quarter of a mile in every direction. From the northwest corner of lake Isabella a good portage of less than a mile and a half leads to Lac la Plonge, whence another good path a little over three-quarters of a mile long runs through the woods to the Frances mine. The route from Michipicoten Harbor to the Frances is about twenty-seven miles long, and of this less than half the distance is by water.

Frances Mine to Dog River

There are two routes from the Frances mine to the Dog river—one by Paint creek, which is descended from Rawlinson pond, on which the Frances is situated, to the Dog river, which it enters about two miles southwest of Heart lake. This route is a good one in high water, as no portages are necessary, but in low water it is not easy, and several short carries have to be made. The other route, and the one more usually followed in going to or from White River station, leaves Paint creek about a quarter of a mile below Rawlinson pond, and strikes northwestward by an excellent

10 Seventh Rep. Bur. Mines, 1897, pp. 184 ff

11 Eighth Rep. Bur. Mines, 1899, p. 136, etc.

portage of about one mile to the Dog river. In high water the portage need not be so long, and the canoe may be put into the water at about three-quarters of a mile from Paint creek, but when this is done a small carry has to be made in going up stream on the right bank, which is avoided by the longer portage across the river. The portage reaches the Dog river in the big bend of the stream, a quarter of a mile below the first small rapid below Heart lake. In descending the Dog river without going to the Frances mine, the entrance of the portage trail to the Frances is not passed, as the portage to avoid the rapids in the big bend leaves just across the bay from the small rapid above mentioned, and on the opposite side of the river from the Frances trail.

Frances Mine to Iron Lake

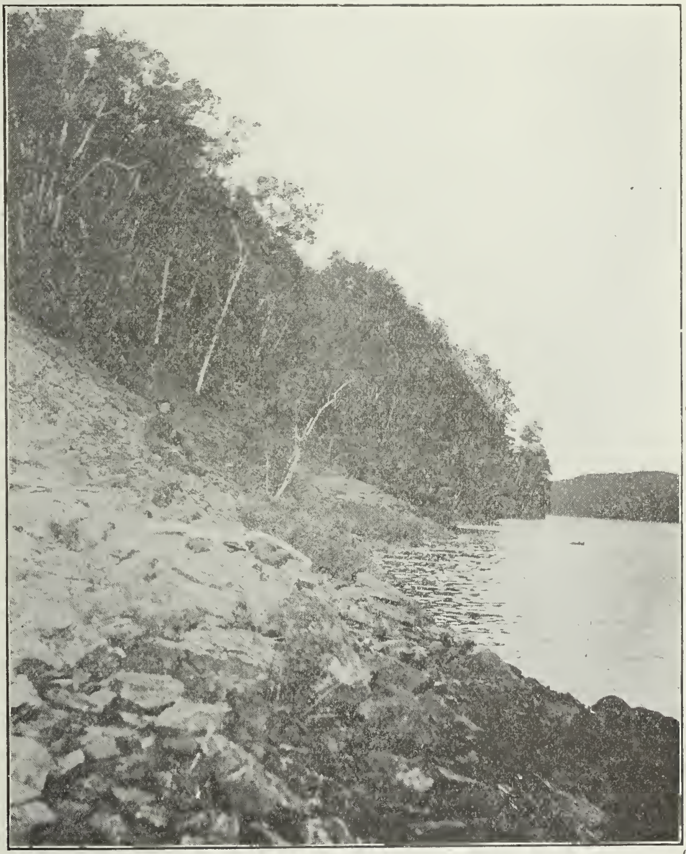
The route from the Frances mine to Iron lake is in part by the Dog river. Just below the mouth of Paint creek is the small chute in the Dog river known as the Rapid of the Drowned. Immediately above the first rapid below this chute and at rather less than half a mile below the Rapid of the Drowned, the portage trail leaves the western bank. There are three portages, all in excellent shape, with good paths

Iron lake.

across the sandplains through the Banksian pine barrens. The first portage is a little more than one-half mile long, and leads into Pitch Pine lake. The outlet from Pitch Pine lake into Iron creek is often shallow, and a short lift is sometimes made here into Iron creek. Iron creek is ascended for less than a hundred yards when the second portage leaves from a small swampy bay on the west side. The second portage, less than one-half mile long, conducts the traveller into a small clear-watered pond which is crossed, and the third portage taken. This portage is said to be the best trail in Michipicoten district, and is so level that we took our loads across it in a wheelbarrow. It is about three-quarters of a mile long, and leads into Iron creek rather more than a mile below the lake of the same name.

Iron lake is a beautiful sheet of water, somewhat less than two miles long and roughly stellate in shape, having five pronounced arms—two opening to the east and

three to the west. Iron creek flows out by the southeastern bay. From the northeastern bay a short canoe route leads by Sigami creek and Sigami lake to Nichols lake. From the southwestern bay a route of three portages, divided by two small ponds—Cleawater lake and Spring lake, may be taken to the Dog river, which it reaches about four miles and a half below the entrance of the other route to Iron lake, just described. This is the usual path to Iron lake taken by voyageurs coming up the Dog river from lake Michi-Biju. From the middle western bay known as Minnesota bay, a trail leads a little south of west. For the first two miles, as far as Bole lake, the path is a good one, but beyond Bole lake it is not easy to follow, though it is traceable with some difficulty as far as the eastern branch of the Pucaswa river,



Iron lake.

about nine miles west of Iron lake, and is said by the Indians to lead to the shore of Lake Superior. From the foot of the northwestern bay a trail leads to several small lakes, and at the point where Iron creek enters Iron lake, a short and easy route leads up by that creek and its expansions to Little Beaver lake.

Dog River to Lake Michi-biju

The route from Dog river to lake Michi-Biju is now seldom used. It leaves the Dog river at the mouth of the small brook entering the main river from the west about a mile and a half below the point where the lower route leaves the Dog river for the southwestern bay of Iron lake. A short distance up this brook a carry is

made past a fall of some ninety feet, over a steep hill into Ekinu lake—a narrow sheet of water rather more than two miles long. From its southern end a portage a mile long leads through a new brulé to Mud lake. Mud lake, which might more correctly be called a marsh, so difficult is it to dig one's way through it by canoe in midsummer, is about three-quarters of a mile long. At its southern end a choice of routes is open to the traveller. One to the southwest leads directly by a portage of two and a quarter miles to Michi lake; the other is much more roundabout, though with shorter portages and is by several small lakes and streams to the Goosefeather river, which is ascended to Michi lake.

Lake Michi-biju to Lake Superior

There are two routes from lake Michi-Biju to Lake Superior, and neither of these is good or much used. One leaves a bay at the entrance of a small stream and leads by a number of small lakes connected by portages, to the Floating Heart river. This stream, with its expansions, is descended to a little below the foot of Floating Heart lake, where a portage leads through a gorge to Cameron lake. From the southern end of Cameron lake the route leads back into the river, which is descended for about one-half mile, when the portage leaves its southern bank. The trail thence is by a number of small lakes to Lake Superior. The other route, and the one more generally used, leaves Michi lake by a small stream which is descended for a little more than half a mile, with several short carries, to its junction with the Goosefeather river, which is ascended for about two miles. For this distance the creek is shallow in low water, but as a rule only one portage, and that a short one past a log jam, is necessary in high water. From Goosefeather river a chain of eight small lakes and nine portages leads to Lake Superior, the route entering Dog River harbor. Only two of these portages are long—the first and fourth from Lake Superior, the former being two and three-quarters miles long, and the latter rather less than a mile and a quarter.

Frances Lake to Lake Kabenung

There are two routes from the Frances mine to Kabenung lake. One is by the Dog river to Heart lake. From the north end of Heart lake the portage taken is not that one by lake George, but along the Dog river itself. The Crayfish river enters the Dog river between Knife lake and Heart lake, and this stream is ascended about a quarter of a mile to Crayfish lake. From the foot of a long narrow bay which opens to the east of Crayfish lake, a good portage of a little over half a mile leads into Kabenung lake. The route enters the northwestern part of Kabenung lake, about one mile and a half west of the narrows. In high water in going from Kabenung lake to the Dog river, the Crayfish river, which is rather rapid, is sometimes used. The other route from the Frances mine to Kabenung lake is taken from Paint creek just above Rawlinson pond. Here a portage a little over a mile long leads to Paint lake. Paint lake and Sage lake together have a length of about three miles and a half, but there is a short stretch of river in between the two on which two unimportant rapids occur. The eastern end of Sage lake is divided into two bays. The route from Paint lake by several lakes and portages to the headwaters of the Doré river leaves by the southern bay, while from a point about half way along the shore of the northern bay a very short portage leads into Skunk lake. Skunk lake is a small clear-watered pond a little more than half a mile long. A short portage leaves it from the western bay at its north end, and falls into the southern part of Western Kabenung lake just at the foot of Big island.

Lake Kabenung to Magpie River

The route usually followed from Kabenung lake to the Magpie river leaves the former body of water by a small stream, known as Elmo creek, which flows into the eastern side of a bay on the southern side of Eastern Kabenung lake about a mile

and a half east of the Narrows. The stream is ascended for a few hundred yards into lake Elmo. From lake Elmo to Lac Poisson Gris the stream or its small expansions are followed, five short portages being necessary. The route leaves Lac Poisson Gris about half way along the southern shore of the eastern bay, and a short carry is made to Muskrat lake. Muskrat lake is a ragged sheet of water filled with islands, and some two miles from north to south. The route does not, however, follow the main arm; and soon after, leaving the portage from Lac Poisson Gris, turns to the west through a narrow channel into a round bay to the entrance of Elmo creek, where a portage is made into lake Alabama. Lake Alabama consists of two ponds joined together by a narrow, sluggish channel. A short portage leaves the northeastern part of the lake, and leads into Fishhook lake. This the route leaves near its southern end by a carry into Elmo creek, here sluggish and meandering, through a wide meadow. This is ascended for less than half a mile, with a short lift necessary in low water, as far as the entrance to the Grand Portage, which leaves the creek here dwindled to very small proportions, on its southern side. From this point there is an alternate route to Kabenung lake from the one which I have just described which goes by Princess lake and several small beaver ponds lying north of it to Brant lake, whence the route is past Scott's Camps to Lonely lake, and thence by a long portage of nearly two miles, broken by two small ponds, to the eastern end of Kabenung lake.

The Grand Portage

The Grand Portage is some three and a half miles across, but this distance is broken by three small ponds which may or may not be made use of by the traveller. On the eastern side of the Grand Portage is the Big Marsh, a very shallow pond less than three-quarters of a mile in length, lying in a wide grassy meadow. A portage of less than half a mile leads from the Big Marsh into lake Maguire along the shore of Evans creek, which flows to the Magpie. Lake Maguire has a length of a little less than a mile, and is irregular in outline. From its eastern end three routes leave, and all lead to the Magpie. One starts from a small bay near the centre of the eastern part and connects lake Maguire with the headwaters of Catfish creek. This route is very seldom used and has already been briefly described. The route usually followed by the Indians from lake Maguire leaves the eastern part in a bay to the north, close to the outlet of the river, where a short portage is made over flat rocks into lake Kapinchigama. The general form of lake Kapinchigama is that of a cross, the main arm lying north and south. The route leaves the eastern arm on the north side, whence a portage of a few hundred yards leads to a small round pond. From this pond another portage leads into Lund lake. From the eastern end of Lund lake, which is three-quarters of a mile long, a short portage is made into lake Pasho-Scoota. From a shallow bay in the extreme eastern part of lake Pasho-Scoota an Indian hunting route leads northeast to several good-sized lakes and ponds, and almost from the same point another portage trail runs south for half a mile over rolling rocky ground and through a beaver marsh to Godon lake. From the southern end of Godon lake a sluggish stream is descended for less than a quarter of a mile, whence a portage is made into the northern end of Pyrrhotite lake. Pyrrhotite lake has two bays opening to the west. A small creek flows into the most northern of these bays, and from its mouth a shorter and more direct route than the one just described leads to lake Maguire. The first portage which leaves lake Maguire about half-way between the entrance of the trail to Catfish creek and the outlet of the lake, runs through a muskeg for about half a mile into Island lake. This is a small round pond one-half mile in every direction. From its eastern end a carry is made on the southern side of a small creek into Clearwater lake. Clearwater lake, a little less than three-quarters of a mile long, is left at its eastern end, whence a portage follows along the eastern side of the creek into a small muskeg pond. From this pond the portage leads close to the north shore of the creek for half a mile into a small expansion of the stream close to Pyrrhotite lake. In high water no further portage is necessary, but when the

water is low, a carry of a few steps has to be made just at the entrance into Pyrrhotite lake. On this route the portages are much better cut out than on the northern and longer path; but it is seldom uesd by the Indians. From Pyrrhotite lake the route to the Magpie leaves by a short portage on the western side of a small stream entering at the southeastern corner. This portage leads into lake Marian. Lake Marian consists of two ponds, each about half a mile long, joined together by a narrows, where the portage is usually made excepting in very high water. The route does not go to the extreme south of lake Marian, but leaves on the east side by a narrow sluggish channel, just south of the narrows. This channel soon expands into a round pond, from the south side of which a portage of about seventy-five yards leads to Punk lake. From the southeastern end of Punk lake three portages, separated by two ponds, lead to the Magpie river, the first one from Punk lake being about three-quarters of a mile long, the next one half mile, and the last into the Magpie, a little over a mile. The route reaches the Magpie just below a high ridge of diabase, which here traverses the river and about a mile above McKinnon's bridge.

Missanabie to Magpie River

In entering the country which we had to examine during the past season, we came in from Missanabie station by a route seldom followed; and although it lies on the east side of the Magpie river, and is hence outside of the limits of this report, still for the benefit of those who may attempt to follow it in future it may be well to give a short account of it here. The route leaves Dog lake, on which Missanabie station is situated, about nine miles from the railway, from the foot of the southwestern bay, just opposite the deserted houses of the Emily mine. The first portage leads for three miles over a rough, rocky country, for the most part burnt clean, into Jackfish lake. Jackfish lake is of extremely irregular shape, having long arms stretching in every direction. It is about three and a half miles long, but is not followed to its extreme eastern end. A stream is entered on the northern side about two and a half miles from the portage to Dog lake, and is ascended for about a mile through its various meanderings into Qua-ka-geshick lake, a small lake a little more than a mile in length. The route leaves it about half way down its northern side by a portage of half a mile which leads into Twin lake. Twin lake consists in reality of two small lakes joined together by a stream about three yards long, where a rapid occurs and a portage is necessary. The route leaves the western end of the most northern of the lakes, and a short portage is made across a lake terrace into a small pond. From the north end of this pond a short portage leads into a second pond, from which a trail if less than half a mile leads across the hills into Goodreau lake. This body of water is extremely crooked and ragged in shape. From a small southwestern bay a route may be followed to the headwaters of McVeigh creek, and from its northwestern bay the route goes to the Magpie. The portages up to this point are fairly good, but from this point on are almost impossible to trace. Leaving Godreau lake, three shallow ponds, each rather less than half a mile long, follow, separated by short portages. From the third pond a small stream is descended for about half a mile, and a portage taken on the northern bank at the head of a series of falls. The portage leads over rough rocky hills, through a treeless country for half a mile, and falls into a small grassy-bordered pond known as Paddy's lake. The next portage leaves just across from the last, and is made into lake Kamshogocka. Lake Kamshogocka is the only lake of any size on the route other than Jackfish lake. Its shores are high and rocky, and the scenery would be very pretty were it not for the absence of green timber. The lake is about one and three-quarters miles long, and lies about north and south. The route enters by a round bay on the eastern side, separated from the main lake by a narrows, and leaves at the north end by Cradle creek, formed by the union of several brooks entering lake Kamshogocka. Cradle creek, a small stream of about ten yards average width, flows into the Magpie near the point where that river, after a course of some eight miles southward from Grasett

station turns to the west. The distance from lake Kamshogocka to the Magpie river by Cradle creek is about four miles, and the general direction of the stream is about north. Eight short portages are necessary between the lake and the river, none of which are long. In general the route from Dog lake to the Magpie river is a poor one, and is only suitable for small canoes, and even then when lightly loaded.

Canoe on Magpie river.

GENERAL CONDITIONS IN THE REGION

In general the forest on the north shore of Lake Superior is northern in character and differs materially from that of southern Ontario. It is characteristically evergreen rather than deciduous. Unlike the forest growth on the rich clay river flats bordering the various streams north of the Height of Land, for the most part it is not healthy and luxuriant, but growing on a rocky or light sandy soil, and exposed to the force of almost unceasing winds from Lake Superior, it is usual to find the trees of a stunted, knotty character.

The Forest Resources

The principal forest trees are white spruce (*picea alba*) black spruce (*picea nigra*) tamarack (*larix Americana*), cedar (*thuya occidentalis*), balsam (*abies balsamea*), white birch (*betula papyrifera*), aspen poplar (*populus tremuioides*), balsam poplar (*populus balsamlfera*), and Banksian pine (*pinus banksiana.*) Sugar maple (*acer saccharum*), soft maple (*acer rubrum*), swamp elm (*ulmus Americana*), black ash

(*fraxinus sambucifolia*), yellow birch (*betula lutea*), white pine (*pinus strobus*), and red pine (*pinus resinosa*), all occur in the Michipicoten area, but are not predominating forest trees. Probably the best red and white pine seen was on Iron lake, and though there are small patches of these valuable trees throughout the area, it is never in large enough quantity nor sufficiently good to be valuable as timber. Stunted red maple may be seen on nearly all the high hills, but sugar maple is not so commonly distributed. Clumps of fairly large trees occur, however, in shallow hollows between the hills at several points on the west side of the Magpie, notably just north of Maple lake, about a mile west of David's lakes, and near Maiden's Leap mountain on the south shore of lake Michi-Biju.

Very little of the timber in the area will be useful for lumber, though there is much that will be valuable as pulp wood. The broad sand-plain which borders the Pucaswa river near its mouth is covered with a healthy growth of spruce, birch and poplar. There is a stretch of very good forest westward from Cameron lake north of Lost lake to Maple lake, and also southward and southwestward from Iron lake. The timber around Kabenung lake and across the Grand Portage is poor, though it appears to improve in character southward and southeastward to the Magpie river.

The common shrubs of the area include many species of willow (*salix*), mountain maple (*acer Pennsylvanicum*), white alder (*alnus incana*), green alder (*alnus viridis*), red cherry (*prunus Pennsylvanica*), choke cherry (*prunus Virginiana*), mountain ash (*pyrus Americana*), service berry (*amelanchier Canadensis*), hazel (*corylus Americana*), and juniper (*juniperus communis*). Hawthorn (*cratægus coccinea*) is rare, but is found at several points.

Like most parts of Northern Ontario, great stretches of the Michipicoten area have been swept of their timber by forest fires which devastate parts of the country almost every year. It is unfortunate that nothing can be done to lessen, if not stop entirely these annual ravages, because though the timber of the Michipicoten is not as valuable as that of other more favored localities, still much of it will be required for local use by the various mines, which I feel confident will in the future open along the iron ranges, even if comparatively little is fit for export. By far the largest burned area is the immense stretch which extends south from the Canadian Pacific railway. The northern boundary of this fire-stripped tract may be said to be an irregular line extending from a point about two miles north of Iron lake on the west to a point on the Magpie river about three miles north of McKinnon's bridge. On the east, south of McKinnon's bridge, there are wide areas along both sides of the Magpie deprived of their timber as far south as the mouth of Catfish creek. There are patches of brulé on Iron lake, at the southern end of Mud lake, and westward to Miron lake, around the Frances mine, at the western end of Paint lake, on Heart lake, on Kabenung lake, and at many other places. Most of these areas were apparently burnt over some years ago, as already in many places a healthy growth of young trees has started.

Soil and Climate

Compared with the rich clay soil found north of the Height of Land, the shallow soil on the rocky hills of Michipicoten, and the sand- or gravel-filled valleys, are from a standpoint of fertility in marked contrast. In fact, very little of the land of the Michipicoten area seems fit for general cultivation, though I believe if the timber were removed, much of it would be fit for pasturage. Many of the wide dried-up marshes surrounding shrunken lakes, or occupying the position of former lakes, are covered in midsummer with as plendid growth of wild grass, very suitable for cattle, and in many of the more completely burnt areas fine grass crops may be seen growing in the timber denuded country. There is a small patch of fertile land lying along the shores of a small creek entering Otter Cove; again, some good stretches occur along the Floating Heart river near Lost lake, and at various other places, but none of these are of any size. The summer is apparently hardly long or warm enough to grow wheat, though oats seem to ripen and potatoes usually are a successful crop where tried.

The climate of the Michipicoten area is for the most part that of the whole of the north shore of lake Superior. In winter the snowfall is heavy, and in summer the rainfall is generally great. In winter low temperatures are common (as will be seen by a glance at the meteorological observations made at White River station), while in summer it is very unusual for the temperature to rise much above 80º (Fahrenheit), and in general it is much lower. The nights are always cool and are often so cold that summer frosts occur. These, however, are rarely heavy. The winter may be said to last from the beginning of November to the middle of April, but there is little growth till the end of May. In general the climate is more severe than in the country north of the Height of Land almost as far as James Bay, the winters equally long and quite as cold, and the summers on the whole shorter, rainier, and not nearly so warm. The difference may in general be said to be due to the proximity of the Michipicoten country to the icy waters of Lake Superior on the one hand, and to the protection afforded to the Hudson's Bay slope north of the Height of Land by the rocky hills which border Lake Superior on the other hand.

Game and Fish

Game is fairly common in the Michipicoten area. Since many of the Indians have given up hunting and have taken to living by means of whatever work they can get near the Lake Superior shore, game in general may be said to have rapidly increased. Caribou and red deer are espesially common in many parts of the country, and though few moose were seen by my party during the past summer, still, I understand from the Indians that this large and splendid animal is not rare in Michipicoten. Bears also are common, especially near the Lake Superior shore, where they find abundant agreeable food in the numerous berries which cover the rocky hills towards the close of summer.

Martin, mink and foxes are uncommon according to Indian report, but I was really surprised at the number of beaver in the region. In our frequent traverses across country we were constantly coming upon fresh dams built by these interesting animals, and in many places the flooded marshes and enlarged ponds caused by these dams were observed to have decidedly influenced the physiography. This winter I am afraid many of these beaver will go, as once the Indians know of their whereabouts, they cannot resist the temptation of partaking of so dainty a morsel as beaver meat. The killing of the beaver by the Indians is particularly dangerous, as it means practically the extermination of the animals in the particular part of the country where the Indians hunt, since it is their custom to wipe out an entire colony of beaver and leave none to breed.

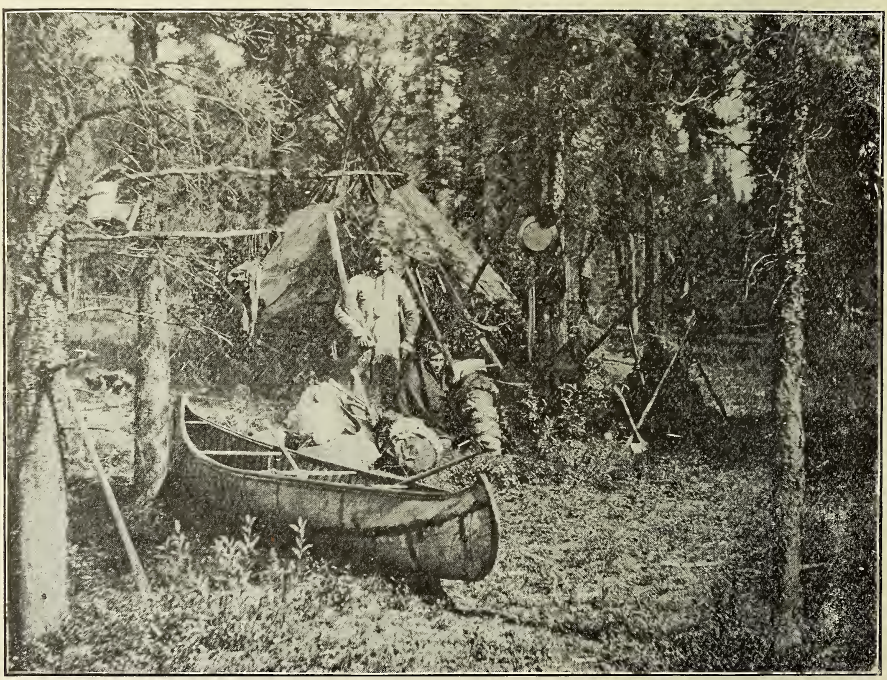
Rabbits were very common in Michipicoten during the past summer, but muskrats were noticed to be especially rare.

Nearly all the larger inland lakes and even many of the small ones are well suppiled with fish, but not with trout, as most people imagine. Pickerel, pike, and suckers are the commonest fish. Brook trout are found in the Pucaswa river, in the Magpie river, and in many of the small brooks near Lake Superior. The mouths of these various streams are a common resort for the Indians during the early autumn when the larger lake trout ascend the streams. White fish are to my knowledge not found in any of the lakes west of the Magpie, though they are plentiful in Dog lake and other lakes west of that stream; and are of course the principal fish in Lake Superior. It is remarkable that Michi-Biju lake, Michi lake, and Katzenbach lake contain no fish, although they are all good-sized bodies of fine clear water. The absence of fish is said by the Indians to be due to the presence of certain sulphur springs, but I could find no visible evidence to support this hypothesis.

The Native Inhabitants

There are now very few Indians left in Michipicoten, and those who still remain have lost most of the fine qualities characteristic of the Ojibway Indian, to which

tribe they belong. Most of them spend their summers living in small wooden houses or in cotton tents at White River station or at the new Roman Catholic mission, which is situated on the Lake Superior shore about two miles west of Michipicoten Harbor. At one or other places they find the occasional brief employment, pleasing to an Indian, either in fishing at one or other of the fishing stations, or in acting as guides to tourists or exploring parties. They never seek steady employment, and for the most part take to the woods in October, where the winter is passed in hunting and trapping. Caribou and rabbits are during this season their chief provision. Few of the Indians now depend much on the furs they can trap, and the catch has been so small in recent years that the Hudson's Bay Company's post at Michipicoten river was closed last summer after having been open for the second time since 1898. In general the Ojibways of Michipicoten are fairly well-to-do, though unhealthy like all savages who have come into contact with the white man's civilization. The morale of those who



Indian camp, near Dog river.

live near Michipicoten Harbor is superior to those who live around White River, since a shocking traffic in whisky goes on with the Indians at the latter place. Nearly all of them now speak English, and in a general way it may be said that the uselessness of an Indian increases directly in proportion to his knowledge of English, or in fact any language other than his own. They have long dressed in European costume, which on them looks essentially grotesque and hideous. The birch bark canoe and the birch bark wigwam, once so common and always so picturesque, are now disappearing from Michipicoten, and the unfortunate Michipicoten Ojibway is year by year becoming more and more like the worst class of the white men with whom he now has free intercourse.

The scenery of the district is generally lovely. The numerous lakes of multiform fantastic shapes, indented by deep bays in all directions and dotted by rocky tree-girt islands, the rugged hills seared by the atmosphere of ages, the dark spruce forest extending to every quarter, and the short stretches of lily-filled calm on the rivers

broken by longer sweeps of foaming rapids or falls, or by high-walled canyons—these are all beautiful and give an ever-changing, shifting scene, but always of the same general character. The numerous lakes and the rivers are a continual source of joy to the voyageur throughout Michipicoten. They make travelling by canoe, and camping in the wilderness a delight. The rough rugged coast of Lake Superior, indented by narrow fiord-like bays or varied by cliffs rising abruptly from the water's edge, or by long stretches of sand beach, lends a continual charm to the scenery of the north shore.

Water Power Sites

There are a great many sites of hydraulic power on the various streams in the area under discussion. Perhaps the ones most suitable for early development, owing to their proximity to the shore of Lake Superior, are the falls near the mouth of the Pucaswa river, Denison falls near the mouth of Dog river, and the two series of falls near the mouth of the Magpie river.

During the past summer the writer and his party were the recipients of many kindnesses, and we were courteously aided in our work by the various people throughout this district, but acknowledgments are especially due to Prof. A. B. Willmott, Superintendent of Mines for the Lake Superior Power Company, to Mr. R. W. Seelye, Manager of the Helen Mine, and to Mr. W. H. McDougall of White River.

GENERAL STRATIGRAPHY

The rocks of the Michipicoten Iron Range, like those of all the iron ranges of lake Superior, are geologically of great antiquity. Though presenting some slight points of difference, they closely resemble the rocks of the Vermilion Iron Range, and are probably of practically the same age; but it is somewhat hazardous to correlate rocks of districts so widely separated.

The stratigraphical succession of the region in ascending order may be given as follows:[12]

Lower Huronian	1. Michipicoten schists, etc. 2. Helen iron formation.
Unconformity.	
Upper Huronian	Doré formation.
Post-Huronian	Acid eruptives.
Keweenawan	Basic eruptives.

The Lower Huronian rocks of Michipicoten are doubtless the stratigraphical equivalents of the Archean rocks of the Vermilion iron range, and the Upper Huronian of Michipicoten, the analogue of the same section. In the nomenclature of these series I have followed the usage of previous geologists in the region. The Post-Huronian acid eruptives are usually called Laurentian. The basic eruptives are probably of the same age as the widespread occurrences of similar rocks within the Nipigon or Keweenawan series. All of these points will be considered later in greater detail.

[12] NOTE.—Since this paper was written the Report of the International Committee on the classification of the pre-Cambrian of the Lake Superior region has been published (Journal of Geology, Vol. XIII. No. 2, 1905), and is reproduced elsewhere in this volume. What is here called the Lower Huronian is apparently equivalent to the Keewatin in the Committee's scheme of classification. On the Vermilion Iron Range of Minnesota, for example, the Keewatin is said by the Committee to consist of (1) the Ely greenstone and (2) the Soudan iron formation, which correspond apparently to Dr. Bell's Michipicoten schists and Helen iron formation respectively. The Upper Huronian or Doré formation probably corresponds to the Committee's Lower Huronian. Dr. Bell does not use the term "Laurentian" which the International Committee retain at the base of their scale in eruptive contact with the Keewatin, but apparently the Post-Huronian acid eruptives of Dr. Bell's paper may, at least in part, be included in the Laurentian as defined by the Committee. T. W. G.

Geologic History

In Lower Huronian times were deposited great thicknesses of igneous rocks. These are at times true lava flows, again intrusive sheets, and at other times tufaceous beds or volcanic clastics. Associated with these are true waterlaid sediments. By the close of Lower Huronian times folding of the strata had already commenced and shallow synclines were formed, in which were deposited the coarse conglomerates of the Doré formation; the larger pebbles and the finer material resulting from the erosion of the high land formed by the arching of the strata between the synclines During this time volcanic activity continued, allowing the deposition of further ash-like material within the Doré formation. Subsequent to Upper Huronian times were great intrusions of both acidic and basic rocks, the former taking place when the intense folding of this strata was well advanced, and the latter occurring when the folding had almost or entirely ceased.

The plication of the strata has been most complex, resulting often in closely compressed longitudinal troughs and arches, with more open transverse folds. The former are parellel to the trend of the iron ranges, the latter at right angles to it. The transverse folding has given to the longitudinal folds a more or less sharp pitch which, with the numerous secondary structures developed—cleavage, jointing and schistosity, produce a geologic condition most difficult to study. In a general way the northern Michipicoten Huronian area may be described as a synclinorium with a general eastward pitch and bounded on the south and north by resistant granitic rocks The western Michipicoten Huronian area is in part much less closely corrugated than the northern area, and its structure, which will be discussed later in connection with the special areas, is somewhat different.

As may be well imagined in a region of such complex structure, erosion has produced great irregularity in the distribution of the various formations, sometimes patches of one kind of rock being separated for miles from rocks of similar lithological characteristics.

THE MICHIPICOTEN SCHISTS

Dr. Coleman and Professor Willmott have divided the Lower Huronian of Eastern Michipicoten into four formations, named in ascending order as follows; Gros Cap greenstone, Wawa tuffs, Helen iron formation, and Eleanor slates. These stratigraphical subdivsions are not quite suitable for the northern and western Huronian areas, and some difficulty has been experienced in separating the members of the series and in assigning absolute positions to the divisions made. The decided band of ferruginous sediments which make up the Helen formation may be considered as occupying a definite horizon. In the northern Michipicoten area this formation generally lies close below the Doré formation, but in some parts of the belt masses of schists intervene between the Helen formation and the Doré formation. In the western Huronian area no such close relation between the iron formation and the conglomerate is observable. This varying position of the Helen formation with reference to the Upper Huronian indicates either an unequal denudation of the Lower Huronian previous to the deposition of the conglomerate, or otherwise an unequal deposition of volcanic material after the Helen iron-bearing rocks had been laid down. Again, tremendous folding and faulting, followed by an enormous and, in different parts of the area, very unequal removel of material, have doubtless seemed to alter the original relations existing between the Upper Huronian and the Helen formation giving rise to frequent misinterpretations of the true condition. In some places especially in the northern belt, the width of the Helen formation appears to diminish and at the same time there is a relative increase in the amount of schist overlying it,

which seems to suggest that in these parts of the area towards the close of Lower Huronian times chemical sedimentation was relatively overpowered by volcanic deposition, whereas elsewhere the former still continued.

The lithological equivalents of the Eleanor slates are comparatively rare in the northern and western parts of Michipicoten, and referred to the Helen formation they occupy no definite position, being either below the iron-bearing rocks, above them, or even intercalated with them. In general, however, (though sometimes in no close relation whatever with the iron formation), they are intimately connected with the Helen formation, and are merely an argillaceous phase of it. Still further, the schistose greenstones, common in northern, though rare in western Michipicoten, which may be considered as analogous to the Gros Cap greenstone, no not always occupy the lowest part of the series and are frequently interstratified with the various igneous schists, which in southern Michipicoten make up the Wawa tuff formation.

Owing to this uncertain relative position of the different members of the series, it has been considered best for the present report to neglect the previous terminology and to make only two divisions in the Lower Huronian—a definite division, the Helen formation, to embrace all iron-bearing cherts or their metamorphic equivalents, together with any other sedimentary rocks, either chemically or water deposited, which may be intimately associated with them—and a somewhat undefined division, the Michipicoten schists, to include all igneous rocks whether extrusive or intrusive, together with any sedimentary rocks, however formed, not immediately associated with the iron-bearing rocks of the Helen formation. These sedimentary rocks not associated with the Helen formation would naturally be connected into a separate formation, were it not that the outcrops of the clastics are very few and bear no relation whatever either structurally or chemically to each other. The new classification is to some extent independent of any age considerations, though the schists are generally older than the rocks of the Helen formation, and compose by far the largest part of the Lower Huronian.

The Michipicoten schists consist of a great complex, comprised in the main of definitely igneous rocks varying in chemical composition from decided basicity on the one hand to pronounced acidity on the other, with which are associated rocks of doubtful igneous origin and a very few rocks of sedimentary origin. All of these rocks, whether sedimentary or igneous, are more or less schistose and often receive the name of "green schists" from their very general green color. The definitely igneous schists comprise the following varieties: schistose greenstone, chloritic and micaceous schists, schistose quartz-porphry, quartz porphyry schists, felsite schists, schistose porphyries, carbonate, schists, and finally amphibolites. The questionable schists are either carbonate schists, chloritic schists, or amphibolites. The distinctly sedimentary schists are either schistose arkoses or phyllites.

The Schistose Greenstone

The schistose greenstone is a predominately massive rock, strikingly simulating in the field an altered diorite or gabbro. Its origin is prabably chiefly from these plutonic rocks, though it is possibly derived in a very small part from true lava flows, especially when it exhibits the ellipsoidly-parted structure analogous to that described by Clements as occurring in the Ely greenstone of the Vermilion district. In northern Michipicoten this last texture is very rare, and as a rule the greenstone is a soft rock of medium to coarse grain, generally with a more or less imperfect schistose structure. In texture it is frequently poikilitic but rarely porphyritic.

The principal alteration of the rock has been metasomatic, comprising chiefly the phenomena of sericitation, chloritization, and carbonatization. Two or all of these processes acting together often give the rock a mottled green appearance. In weathering the rock freqently become covered with a pinkish or grayish white crust, which

very often gives it the appearance from a distance of a granite or felsite. Often associated with the schistose greenstone and occasionally grading imperceptibly into it, is a fine-grained, soft, chloritic, highly schistose rock, which is apparently sometimes intruded by the schistose greenstone, but much more often intercalated with it. These much sheared rocks have been tentatively regarded as tufaceous deposits. Their history will be enlarged upon further on.

Petrography of the Schistose Greenstone

Little can be gained by the microscopic study of the schistose greenstone. The original minerals still remaining are plagioclase, hornblende, augite, magnetite, ilmenite and apatite. Both the hornblende and plagioclase are greatly altered; the plagioclase so much so that no more definite mineralogical composition can be assigned to it. With these primary minerals are associated the following secondary constituents —chlorite, quartz, chalcedony, pyrite, zoisite, sericite, epidote, titanite (leucoxene) and carbonate. Chlorite in large irregular areas eating into both the feldspars and hornblende, is the predominating mineral, though epidote in large radiating sheaves, and zoisite in tabular aggregates have frequently replaced the hornblende and invaded the plagioclase areas as well. Sericite and a carbonate which is sometimes ferruginous, as judged from its frequent alteration to limonite, often replaces plagioclase, and quartz, as observed in one instance at least, forms an exact pseudomorph after that mineral. Quartz and carbonate often fill secondary cracks, and these infiltrations are not infrequently rusty from the alteration of the carbonate.

Distribution of the Greenstone

The distribution of the greenstone is extensive throughout the northern Michipicoten area. The shores of Sigami lake, north of Iron lake, are entirely composed of this rock, and it forms the prominent part of the low hills stretching westward from that body of water beyond Nichols lake and eastward to the north of Pitch Pine lake, to the Dog river. Again it appears prominently south of the Frances mine towards Lac à la Plonge, outcrops at frequent intervals along the southern part of Paint lake and of Sage lake, and southward from Kabenung lake, towards the contact with the Post-Huronian acid eruptives.

By intense dynamic strain the schistose greenstones are sometimes metamorphosed to talcose and chloritic schists, though these rocks are formed more frequently from the finer-grained schists associated with the greenstone, which were probably originally tuffs or lava flows, or may even have been water-formed argillites. Definite proof of the extrusive igneous origin of some of these rocks is found in the frequent occurrence of amygdaloids. With these amygdaloids are sometimes associated rocks which contain no amygdules, but resemble closely the groundmass of the true amygdaloid or are even more highly sheared. These very schistose rocks sometimes occur quite independent of, and at long distances from the nearest amygdaloid, but from their lithological resemblance to the latter, and because of the occasional presence within them of small rounded fragments which resemble lapilli, they have generally been regarded as altered tuffs, though they may in part be very much altered phyllites. The amygdaloidal structure is remarkably well shown on the weathered surface of the true amygdaloid, and the frequent occurrence of amygdules in a soft groundmass so strikingly simulates the macroscopical appearance of the Doré conglomerate that in several instances in the field the lava was with difficulty distinguished from the conglomerate.

Originally the groundmass of the amygdaloids was probably a basic glass or a fine-grained mass consisting chiefly of plagioclase and some ferromagnesian mineral. The latter has now entirely disappeared, but under the microscope the former is frequently recognizable and is seen to interlock in ophitic structure with the plates of chlorite developed from the antecedent ferromagnesian mineral which was very probably augite.

The laths of altered plagioclase are often entirely replaced by secondary chlorite, chalcedony and carbonate, the latter more or less decomposd with the formation of hydrous iron oxide.

The amygdules contain chlorite, carbonate and quartz, sometimes consisting of one of these minerals, sometimes of two, and often of all three—thus exhibiting amygdules of different colors, although predominately whitish or yellowish or reddish due to the oxidation of the carbonate. When the three minerals are present, ordinarily the outer rim, along the edge of the amygdule, consists chiefly of chlorite with a little carbonate, then one of quartz, at first coarse-grained but becoming saccharoidal towards the centre, and finally often a central core of carbonate. At other times apparently the paragenesis is reversed, and all the carbonate forms subsequent to the quartz.

The amygdaloidal chloritic schists outcrop immediately north of the range at Iron lake, and in some places south of it towards Windigo mountain, again north of Sigami lake and near the shore of the marsh on the portage between the Frances mine and the Dog river. The lateral extent of the true amygdaloids is small, and the rock often grades imperceptibly into schists which show no amygdaloidal structure. The latter—the common chlorite schists—have a widespread distribution intercalated with the various other schists throughout the region.

The schistose quartz porphyry and the quartz porphyry schist are chemically of practically the same composition, but they are apparently of slightly different mode of origin, the latter being effusive and the former intrusive, though probably at no great distance beneath the surface existing at the time of intrusion. This relation between the two rocks is judged from the small embayments of schistose quartz porphyry extending into the quartz porphyry schists. It is possible, however, that the schistose quartz porphyry may be merely a less mashed phase of the quartz porphyry schists, though the great linear extent of these rocks seems to preclude this hypothesis.

The quartz porphyry schist is often intensely sheared, splitting into thin bands a fraction of an inch in thickness. The schistose quartz porphyry on the other hand is remarkably massive, and is frequently shown topographically as the summit of a low ridge standing above the more friable quartz pophyry schists, with which it is apparently always connected. As it is occasionally granitoid in texture, it is sometimes with difficulty distinguished from the fine-grained porphyritic granites of the same age as the immense granite intrusions which succeeded the deposition of the Upper Huronian rocks.

Microscopically the quartz porphyry schist is a nearly gray greenish or pinkish rock containing numerous blebs of clear glassy quartz. The schist sometimes shows slight variations in color and texture, indicating successive flows resembling bedding planes. These planes are usually in accordance with its highly developed schistosity Beneath the microscope its decomposed groundmass is seen to be composed chiefly of the following minerals: orthoclase, plagioclase, sericite, quartz and chlorite. In the more altered varieties the orthoclase and plagioclase are entirely changed to sericite, but in others the alteration has not proceeded so far. The plagioclase is a somewhat acid oligoclase, but occasionally it is basic as andesine. In the metasomatic replacement of the feldspars, chalcedony and carbonate have always developed in connection with sericite. Where not decomposed, the groundmass shows a distinct felsitic texture. There is a marked tendency for the alteration products to arrange themselves in parallel lines along the planes of foliation. The phenocrysts are of three kinds: quartz, plagioclase and orthoclase. Rocks in which quartz is the chief phenocryst are the most common. The phenocrysts are for the most part relatively large, and those which are of feldspar have not undergone as great alteration as the groundmass. The quartz is usually rounded, but sometimes shows the faint outline of the double pyramid. Orthoclase appears in large Carlsbad twins, and plagioclase, which ranges in acidity from acid oligoclase to andesine, shows twinning both after the albite and pericline laws. Both quartzes and feldspars have been granulated, and the

latter are often surrounded by a halo of secondary minerals—quartz, sericite, carbonate and hydrous iron oxide. Occasional large plates of chlorite may represent original phenocrysts of biotite bleached of their iron constituent.

The schistose felsites and the felsitic schists are the less silicious equivalents of the schistose quartz porphyries and the quartz porphyry schists, into which the former imperceptibly grade by the addition of more quartz in the groundmass and the development of phenocrysts of the same mineral. Owing to the extensive sericitation which both the quartz porphyry schists and the felsite schists have undergone, they might be more correctly classed together as sericite schists. Chemical changes have considerably altered the quartz-porphyry and felsite schists, resulting at many points in their being greatly silicified. Again, secondary carbonates have been extensively formed. From the oxidation of these rocks result the rusty silicified schists common in many parts of the district. It is possible that much of this carbonate and silica was original and was deposited between flows as small lenses of chemical sediment interstratified with the more extensive igneous material. The sericite schist of both the quartz-porphyry and the felsite facies are among the commonest rocks of the Lower Huronian in northern Michipicoten, and are frequently found immediately underlying the Helen formation and occasionally overlying it. They are not so commonly distributed in western Michipicoten, but occur prominently just west of Fall creek and elsewhere. When they have undergone silicification and carbonatization, they are sometimes almost indistinguishable from some of the cherty carbonates of the Helen formation.

Other Types of Schist

Closely resembling from a textural standpoint the quartz-porphyry schists and felsite schists, are the various porphyritic schists, which represent the effusive equivalents of plutonic rocks varying in acidity from basic syenites or acid diorites to gabbros. A syenite porphyrite schist is quite commonly connected with rocks of the Helen formation in western Michipicoten, especially north of Brown lake. The hand specimen shows a highly schistose dark gray rock, resembling a chlorite schist and specked with small pinkish blebs of feldspar. Beneath the microscope the large phenocrysts stand in marked contrast to the fine-grained groundmass. The phenocrysts consist chiefly of orthoclase and of plagioclase, which does not exceed the basicity of andesine. Both orthoclase and plagioclase are decomposed, much strained, and sometimes cracked and faulted. The groundmass, which is entirely altered, consists of a mass of chlorite, sericite, quartz, calcite, epidote, ziosite, and hydrous iron oxide.

The diorite-porphyrite schist which also occurs in the western Michipicoten Huronian, commonly contains phenocrysts of hornblende, of plagioclase, and a very few of biotite, the groundmass consisting of altered feldspars, quartz, chlorite, calcite and pyrite.

The various carbonate schists, calcareous, dolomitic, or sideritic, represent the extreme phase of the carbonization of the other green schists, more particularly the less massive phase of the schistose greenstone, which they closely resemble in physical appearance, and from which they differ chemically in the increase in the quantity of carbonate and, to a less extent, of silica.

The rock in the field is often hardly distinguishable from a much altered diorite or gabbro, but the more completely metamorphosed specimens are really impure limestones, dolomites, and siderites. For instance, at the extreme eastern end of Kabenung lake there is a rock of undoubted igneous origin, now almost completely composed of calcium carbonate, with small amounts of muscovite, zoisite, chalcedony and a very few much altered plagioclases, showing twinned striation. Again part of the coarse-grained schist on the Angel's Night Cap at Iron lake is composed principally of carbonate with light green chlorite, quartz, and some altered plagioclase. The quartz often forms exact pseudomorphs after plagioclase, while the carbonate replaces both

plagioclase and the original ferromagnesian mineral, of which chlorite is the bleached successor. Carbonate is also independently deposited in cracks. Chlorite is sometimes apparently a metasomatic product of plagioclase.

A sideritic schist ocurs on the portage from Pyrrhotite lake to Godon lake, which contains so much iron carbonate that by its oxidation it has given rise to small pockets of impure iron ore, of no economic importance. These deposits of siderite in many cases doubtless have resulted from the infiltration of material leached from overlying or adjoining rocks and deposited in the interstices of the schistose greenstones or other schists, but it is also due in part to the direct alteration of some of the original minerals, probably chiefly the ferromagnesian minerals—hornblende or augite.

The phenomena of chloritization, silicification, carbonatization and kaolinization, of hornblende or augite, may be theoretically expressed as follows:

$$5 \{ (Ca, Mg, Fe) O + (Al, Fe)_2 O_3 - 4SiO_2 \} 12 H_2O + 15 CO_2 = 5 CaCO_3 + 5 Fe_2O_3 + 5 FeCO_3 + 5MgCO_3 + 4 H_2O, 5 MgO, Al_2O_3, 3Si O_2 + 4(2H_2O, Al_2O_3, 2 SiO_2) + 9 SiO_2.$$

or the carbonization, silicification and kaolinization of plagioclase (acid labradorite).

$$2 (Ca, Al_2Si_2O_8 + NaAl Si_3O_8) + 3 CO_2 + 6 H_2O = 2 CaCO_3 + 3(2H_2O, Al_2 O_3, 2 SiO_2) + Na_2CO_3 + 4SiO_2$$

Metamorphosed Schists

Besides the peculiar forms already described, due to regional metamorphism, there are a number of other interesting rocks produced both by contact and dynamic metamorphism, more especially the former. Only a very few of these can be discussed in the limited compass of this report. They are apparently of three principal kinds—the epidote schist type, the hornblende schist type, and the biotite schist type. The epidote schist facies shows a rock in which the original mineral constituents, basic plagioclase, and amphibole or pyroxene have been metamorphosed to a mass of epidote, zoisite, quartz, chalcedony, chlorite and often magnetite, but showing sometimes fragments of original feldspars or ferromagnesian minerals. This rock is especially common along the contact of the schist with the large masses of Post-Huronian acid eruptives, especially where narrow sheets of the acid intrusive are intercalated with thin beds of schists. The phenomenon was seen to best advantage in the fire-swept stretch of country just north of lake Charlotte. The epidote schist type is apparently formed from the finer-grained chloritic schists.

Often appearing close to the contact of the post-Huronian eruptives, and even included as small areas within them are rocks of the hornblende schist type. They were also noticed in several places as the product of dynamic metamorphism, or what is apparently so. Beneath the microscope the rock appears entirely re-crystallized, and consists usually of hornblende, epidote, magnetite, quartz, and sometimes plagioclase (labradorite?) with calcite, biotite and chlorite. The light and dark minerals are associated in more or less parallel bands. This rock may be found on the shores of Brant lake, south of the Grand Portage, as narrow bands of included schists in granites, etc.; west of Richardson's Harbor towards Otter Head, in connection with the magnetite schists of McDougall's lake; and elsewhere. The hornblende schist type represents apparently the extreme phase of metamorphism of the chlorite schists. There are phases which are transitional between the chlorite schists proper and the purely hornblende schists. Sometimes the percentage of magnetite increases so much that they pass into magnetite schists. Narrow lenses of a magnetite hornblende chlorite schist (very rich in magnetite) occur on the north side of the Pucaswa river about two miles above its mouth, and these probably represent enriched narrow zones formed by differentiation by compression of some basic igneous rock like gabbro. They possibly resemble on a very small scale the immense lenses of magnetite in horn-

blende and chlorite schists at Sydvaranger in Norway, described by G. Henriksen.[13]

The biotite schist type is much less common than either of the other two, but is seen typically to form low overhanging cliffs, rising ten to twenty feet above the waters of lake Kapimchigama, in the long northern bay, and I observed it at several other points. Megascopically in some ways this rock resembles the carbonate schists. It usually consists mainly of biotite, with lesser amounts of carbonate (calcite), magnetite, muscovite, talc, chlorite, residuary green hornblende, and altered feldspar. Originally the rock was probably a schistose greenstone or allied rock, composed mainly of amphibole (very possibly a paramorph after pyroxene), a little basic plagioclase, and more or less magnetite. However, the biotite, with intergrowths of muscovite, calcite, and chlorite, has almost entirely replaced the original material, though magnetite occurs everywhere quite unaltered as inclusions in all the secondary minerals.

The highly banded gneisses which occur within the granites of Otter Head and elsewhere, often in large areas, are supposed to represent extremely metamorphosed quartz-porphyries or felsite schists, or their deep-seated equivalents. This point, however, will be discussed later in connection with the post-Huronian acid eruptives.

A peculiar black schist was found on the east branch of the Pucaswa river north of David's lakes, and on the portage between Pyrrhotite lake and lake Marian, in connection with the carbonate schist already mentioned. The hand specimen shows a heavy black schistose or even slaty rock. Beneath the microscope the minerals chiefly showing are pyrite, more or less altered and in great irregular clumps, and much less quartz and chlorite. Sometimes the pyrite is in large crystalline areas unbroken by chlorite or quartz, again it is in small specks more or less segregated within streaks of chlorite and quartz.

It has been mentioned that silification is a common metasomatic change in the alteration of the quartz-porphyry schists. It was observed that this change was especially common where the rocks were in eruptive contact with large masses of intruded granite, and occasionally difficulty was experienced in ascertaining which was the intrusive and which the intruded.

The various pseudo-conglomerates which occur so widely in northern Michipicoten are sometimes almost indistinguishable from a waterlaid rock. One of these, the chlorite amygdaloidal schists, has already been described, but several others may be mentioned. Near the shore of Syenite lake occurs an amphibolite, an altered schistose greenstone, throughout which at one particular point rounded fragments very much resembling pebbles, are common. They are, however, all exactly the same, consisting of a mass of epidote, zoisite, chlorite and magnetite, and probably represent the corroded remains of fragments of original schist, into which the irruptive rock was intruded. Another example is the autoclastic rock seen west of Eccles lake (on the east side of the Magpie), and east of Godon lake. Here interbanded, softer and harder layers of felsite and quartz porphyry were first brecciated and then the harder fragments rounded by shearing.

Real Sedimentary Rocks

It has been mentioned that the distinctly sedimentary rocks within the Michipicoten schists consist of schistose arkoses and of phyllites. Schistose arkose has been found to my knowledge in the northern and western Michipicoten areas at only one point, on a small island near the eastern end of Reed lake, as narrow bands in connection with phyllites. The arkose macroscopically is a grayish schistose rock, looking not unlike an altered felsite, with which it may probably be sometimes confused in the field. Microscopicallly it is seen to consist of a somewhat fine-grained matrix of small rounded quartzes, muscovite and chlorite in small flakes, and crystalline calcite, in which are embedded the various larger fragments of quartz and both orthoclase and plagioclase feldspars. The feldspars, which are much altered to sericite and other secondary products, are more common than quartz.

13 "On the Iron Ore Deposits of Sydvaranger, Finamacken, Norway," by G. Henriksen.

Highly schistose chlorite schists, which are definitely known to be sedimentary phyllites within the Michipicoten schists and with no connection with the Helen formation, are very rare. The rocks of this type, however, which outcrop in Dog River harbor, are distinctly sedimentary and have apparently no connection with the Helen formation, the nearest outcrop of which is two miles to the west. Similar phyllites appear on the islands at the east of Reed lake. These phyllites of Dog River harbor and of Reed lake resemble phyllites occurring with the iron formation at Iron lake, and even more so those which border the Doré conglomerate on the south side on the Magpie river, south of McKinnon's bridge. It is impossible from mere lithological reasons to connect these phyllites, without any definite stratigraphical connection, with either the Helen or Doré formations, and they are merely considered with the arkose above described as being sedimentary lenses within the much more extensive igneous material, though they may more correctly be isolated outcrops belonging with the argillaceous rock of the Helen formation or Doré formation.

The outcrop on Dog river is interesting, and I shall describe it somewhat in detail. There are two bands of phyllite. The most eastern band strikes about N. 80° W., and has a very slight inclination from the vertical. It consists of black phyllite interbanded with light grayish phyllite, both more or less rusty, due to the oxidation of pyrite. The outcrop is twenty feet wide. A gravel beach borders the rock on the east side, but at seventy-five feet in that direction an almost massive greenstone schist appears. On the west side of the phyllite lie seventeen feet of light greenish schistose agglomerate, beneath which is a schistose greenstone for twenty-four feet, then seven feet of rusty chloritic schist (which may be sedimentary), and then the second band of phyllite five feet wide and closely resembling the first band in general appearance, but which strikes N. 40° W. and dips northeastward at 52°. Beneath the second phyllite band lie chloritic schists, which appear as if of igneous origin.

In the microscopic cross-section the sedimentary origin of the phyllite is ascertained by the presence of rounded quartzes and of frayed fragmental chlorites or micas. The light gray phyllites seem to owe their color to the presence of considerable sericite, whereas the dark coloring of the blackish phyllites is due to the presence of carbonaceous matter.

The band of phyllites which appears on Dog River harbor outcrops at several points along the portage trail from the harbor to the first lake on the route to lake Michi-Biju.

THE HELEN FORMATION

As already mentioned, the Helen iron formation (in northern Michipicoten at least) occupies a position generally close to the overlying Doré conglomerate, but sometimes great masses of green schist intervene between it and the Doré formation. The relations existing between these overlying green schists and the Helen formation will be seen when the special districts of Morse mountain and the Katossin claim are described later.

The Helen formation consists of a series of allied and related rocks named in order of their importance in the region as follows: banded chert, massive granular chert, sideritic chert, pyritous chert, banded jasper, rusty quartzite, grüneritic and other amphibolitic schists, cherty siderite, and iron ores—hematite, magnetite, pyrites and even pyrrohotite. Between these rocks there is every phase of gradation. Besides these ferruginous rocks the formation includes a number of argillaceous rocks, phyllites, and biotitic and epidotic schists—all undoubtedly sedimentary which are found not only interstratified with the ferruginous rocks but also both above and below them, although always in intimate connection with them. These argillaceous rocks, as already mentioned, cannot be connected with the phyllites at Dog River harbor and at Reed lake, because there is apparently no stratigraphical connection between the phyllites of the Helen formation and the others.

Intercalated with the Iron formation at Iron lake are carbonate schists which were at first supposed to be contemporaneous with the iron formation, but which are in reality sheets of basic igneous rocks, injected parallel to the bedding of the sediments, and apophyses from the wide dikes of post-Huronian basic eruptives which cut the formation, and since their injection much altered by metasomatic changes. They will be discussed in connection with the rocks of which they are a part—the post-Huronian basic eruptives, and are mentioned here, merely because of the deteriorating influence which they exercise on the economic value of the iron formation at certain points.

The Iron-bearing Cherts

The banded chert is composed in its typical form of alternating narrow layers of whitish opalescent chert and silicious hematite or magnetite. In the northern Michipicoten iron range this form is rarely seen, though very common in western Michipicoten. The opalescent chert is usually quartzitic or granulated, and the silicious hematites are impoverished purplish jaspers, with which there is always associated some pyrite, though most of it may replaced by pseudomorphs of limonite. Beneath the microscope the whitish chert bands appear as a homogenous, interlocking, fine grained mosaic of quartz, while the purplish layers consist of much stained quartzes thickly mixed with specks and small areas of hematite, hydrous iron oxide and more or less oxidized carbonate or pyrites.

The banded cherts are often brecciated, and the fragments re-cemented by secondary quartz. In this autoclastic rock the original ferruginous bands appear as angular reddish areas in a matrix of whitish quartz.

The sideritic chert consists essentially of two minerals—quartz and siderite, with which are almost always associated chlorite, sericite, pyrite, oxidation products of pyrite and carbonate, and sometimes microcline and other feldspars. Examined microscopically, some of the quartz is seen to be clastic, but most of it is chemically precipitated, often in the form of chalcedony. Both microcline and chlorite, the former in rounded grains and the latter in plates with frayed edges, are fragmental, and their areas have been greatly reduced by the invading carbonate. Pyrite is frequently an inclusion in both the chlorite and carbonate, and it occasionally develops in secondary veinlets in association with chlorite, carbonate and quartz. Some of the sideritic cherts contain so much chlorite that they pass into cherty sideritic phyllites, of so much microcline that they become sideritic arkoses.

The massive grayish, pinkish or whitish chert, when quite pure and undecomposed, is holocrystalline and beneath the microscope is seen to consist of an interlocking mosaic of quartz. This is the "sandstone chert" of the Michipicoten prospector. It is often markedly rusty, due to the oxidation of iron carbonate, and less frequently iron pyrites, both of which are nearly always present. With an increase of one or other of these minerals, the rock passes into a sideritic chert or pyritous chert.

Occasionally the chert is almost black in color, amorphous, and with its constituent minerals entirely unseparated into bands. This phase, when viewed microscopically, is seen to be composed of a fine mosaic of quartz, often chalcedonic, with a great deal of chlorite in small flakes, and with considerable magnetite or pyrite, or both, as tiny inclusions in the chert or as automorphic grains or aggregates. By arrangement in bands and decrease in the quantity of pyrite this grades into the normal banded chert.

Allied to the granular chert and often almost indistinguishable from it in the field, is a coarse-grained rusty quartzite. This rock beneath the microscope shows tremendous shearing The quartz individuals are drawn out in long ribbons, with a general parallel alignment of the main axes of the grains, but with sweeping curved boundaries. The "ribbons" are surrounded by a mosaic of granulated quartz and are crossed by tiny sutures filled with similar material. The whole has been re-cemented by secondary quartz.

True banded jasper or "jaspylyte," is comparatively rare in the Michipicoten district. It occurs north of Iron lake, on the Katossin claim, on the shore of lake Superior three and a half miles west of the mouth of the Pucaswa, and east of the Magpie, and is hence worthy of mention. It consists of interbanded layers of crimson jasper with either bluish specular hematite or magnetite, or both mixed.

Metamorphosed Ferruginous Cherts

Sometimes the ferruginous cherts are so intensely altered by either contact or dynamic metamorphism that various amphibolitic schists result. These are of three kinds—the grünerite facies, the actinolite facies, and the hornblende facies, depending on the character of the original rock from which the metamorphic rock was derived. Every phase of alteration can be traced from a cherty rock in which the small and few blades of grünerite, actinolite, or hornblende are only distinguishable under the microscope, to those which resemble an amphibole schist formed by the alteration of an igneous rock. The alterations are due almost always to contact metamorphism, although instances resulting from what is apparently dynamic metamorphism are not unknown.

The grünerite type shows remarkably even separation into bands, light grayish green and black in color. The light colored bands are composed of a radiating interlocking belt of long lath-shaped grünerite crystals, containing a very little magnetite and a few residuary quartzes—the remnants left by the invasion of the grains of grünerite. The dark bands consist chiefly of magnetite, with lesser amounts of grünerite and quartz. The magnetite is gaining at the expense of quartz.

The actinolite schist type exhibits macroscopically a light grayish-green rock, often stained with iron rust, generally very highly foliated, and sometimes soft and friable. The thin section shows a mat of fine actinolite needles, almost entirely replacing a quartz mosaic, which is but faintly visible, and holding in their interstices, and sometimes as inclusions, automorphic grains and small aggregates of magnetite. Grünerite at times probably replaces actinolite and the rock then grades into a grünerite schist.

The hornblende schist derived from the metamorphism of a ferruginous sediment resembles remarkably that derived from the metamorphism of a schistose greenstone or chloritic schist, though as a rule the banding is more uniform and the percentage of quartz greater in the sedimentary rock. Beneath the microscope the hornblende schist is seen to contain the following minerals, quartz, with chalcedonic silica, hornblende, epidote, biotite, chlorite, carbonate, magnetite, and rarely apatite, arranged in parallel bands of dark grayish green and black. The grayish green bands consist chiefly of quartz, chalcedony and hornblende the latter gaining at the expense of quartz. Chalcedony, when present, advances almost as steadily as hornblende. Epidote and hornblende with magnetite make up the darker bands. The epidote and hornblende are intergrown in apparently contemporaneous growth, appearing in long attenuated sheaves, with their long axes parallel to the planes of schistosity. The magnetite is contained as inclusions within both epidote and hornblende, and as independent crystals and aggregates between their interstices. No quartz save that which is found as inclusions in the ferromagnesian minerals, is found in the darker bands. A little residuary carbonate and chlorite, still left unaltered from the original rock, are generally present, and these may be in very considerable quantity. Biotite and apatite are comparatively uncommon inclusions. Sometimes there is no magnetite in the rock, but a great deal of both epidote and hornblende and some apatite. In this case the rock has evidently resulted from the alteration of a cherty carbonate rich in lime and magnesia and poor in iron oxides; and probably containing much chlorite.

As may be judged from the products of alteration of the cherty iron carbonate, few of them are pure cherty siderites. Analyses were made of several specimens. One sample from McDougall's promontory on Iron lake gave the following result:

	Per cent.
$FeCo_3$	37.01
$MgCO_3$	7.95
SiO_2	52.36
H_2O, etc	2.+

while other analyses showed lime.

Petrography of the Phyllites

The argillaceous rocks associated with the ferruginous rocks of the Helen formation are phyllites, and rocks derived by metamorphism from phyllites. The rocks of this character, which have been definitely ascertained to be of clastic origin are rare in Michipicoten, though there are a great many doubtful rocks which are now tentatively classed with the Michipicoten schists, and which may really belong with the phyllites. The few occurrences of definitely ascertained phyllites are so widely separated that it would be impossible to classify them as one bed.

Generally the only methods of determining the origin of the phyllites are by their very even banding, by their often pronounced slaty cleavage, and by their direct association with iron-bearing rocks undoubtedly sedimentary, but occasionally the origin is also discoverable microscopically by the presence of decided rounded grains of clastic quartz, or by frayed fragmental biotites or chlorites.

The phyllites are both light-colored and dark-colored. The light- colored phyllite, a very cleavable rock, consists essentially of chlorite and sericite with generally a little quartz. A light-colored tourmaline is occasionally abundant, and there is always probably a little carbonate.

The dark-colored phyllites owe their color to the presence of a large amount of what is apparently carbonaceous material. They are very evenly and often crenately banded in very thin layers of lighter and darker material. The darker material consists of chlorite, biotite, hematite, carbonaceous matter, and a little chalcedonic silica. The biotite and chlorite are arranged with their long axes parallel to the foliation of the rock. The whitish bands are composed of chalcedony, some clastic quartz, light greenish chlorite, and a little hematite. The clastic quartzes are drawn into long narrow lenses wedged in between foils of biotite and chlorite.

By their further metamorphism, owing to the intrusion of igneous rocks, the phyllites alter to epidotic and micaceous schists. The epidotic schists are megascopically rusty weathering fine-grained rocks, often showing banding but very slightly cleavable. Beneath the microscope the banded varieties show layers of epidote, chlorite, zoisite, quartz, chalcedony, and a little hematite and magnetite, intercalated with layers consisting chiefly of magnetite with a little chlorite and chalcedony. The minerals are nearly all secondary, and only some of the chlorite and a few of the larger quartzes, which are drawn out in lensoid shape parallel to the schistosity, are clastic and original. Sometimes the epidote is entirely replaced by zoisite, with which are associated garnet, muscovite, pyrite and chalcedony, and there is sometimes a little original or secondary carbonate.

The micaceous schists show the development of biotite and muscovite in bands, separated by layers composed chiefly of quartz, often chalcedonic.

The degree of alteration of the phyllites varies with their position with reference to the dike or boss which caused their metamorphism, the change being greatest immediately adjoining the eruptive rock, and gradually diminishing away from the contact to the sediment changed only by the general regional metamorphism.

Structure of the Helen Formation

As most of the rocks of the Helen iron formation are of a hard resistant nature, they become fractured, brecciated and jointed rather than cleaved, though the phyllites and their metamorphic products, as well as the altered rocks resulting from the ferruginous sediments, often are decidedly schistose. Pronounced faults in the iron formation may be seen in several parts of the north and west Michipicoten ranges.

Among these may be mentioned one on the property formerly owned by the Minnesota Iron Company, west of Iron lake, two on the prolongation of the Leach lake bands north of the Grand Portage, and one on the portage from Floating Heart river to Cameron lake; doubtless also there are besides these larger and more apparent faults, innumerable instances of minor faulting or shifts of accommodation which are not so easily seen.

Genesis of the Helen Iron-bearing Rocks

The Helen formation is chiefly a chemical sediment, but it is also in part mechanical, as seen by the beds of cherty quartzites, cherty arkoses, and other decidedly clastic rocks which are associated with it.

It has been mentioned that igneous schists rich in iron-bearing silicates (augite, hornblende, etc.) are common in the Lower Huronian. From these igneous schists may have been derived the ferruginous, magnesic and calcic material of the ferruginous sediments. The ferruginous material, leached from the igneous rocks was probably dissolved in the sea water either as carbonate or as sulphate. Owing to the probable excess of carbon dioxide over any other acid present in the dissolving water, it would seem reasonable to suppose that ferrous carbonate was the principal salt in solution. If the water were not shallow, and the ferrous carbonate in solution were not close to the surface of the water, it might sink and be deposited simply owing to excess in solution. Similarly the ferrous sulphate might also be deposited. Contemporaneously with the deposition of the ferrous carbonate, calcium and magnesium carbonates would be formed and deposited in greater or less amount. At the same time that these reactions were proceeding, chert was being formed from a sea water rich in silica (due to the disintegration of the silicates), and more or less mechanical material derived from the decay of the surroundng rocks was laid down with the more extensive chemical deposit. Within the oxidizing influence of the atmosphere near the surface, some of the carbonate may have been oxidized, and unless again carbonatized by the abundant carbon dioxide probably present in the water lower down, would sink to the bottom as hydrous ferric oxide. The ferrous sulphate in contact with the oxidizing influence of the atmosphere would similarly be oxidized to basic ferric sulphate. The phyllites of the Helen formation contain a great deal of carbonaceous material. It the ferric oxide and ferric sulphate were deposited within the influence of this material, then probably the ferric oxide would be reduced to ferrous oxide and unite with the carbon dioxide simultaneously formed, and ferrous carbonate would result, while the sulphate would be reduced to sulphide by the organic material. This may account for the abundant iron pyrites deposited with the various cherts of the iron formation.

Professor Van Hise considers that the carbonate and sulphate, transported to the water, were oxidized and sank to the bottom in this condition as ferric oxide and basic ferric sulphate. They there came in contact with carbonaceous matter, and carbonates and sulphides resulted, as above outlined. This may be the correct hypothesis, but it seems remarkable that extensive oxidation should have proceeded in water sufficiently rich in carbon dioxide to dissolve the carbonates, especially at depths away from sub-aerial influence, where the water may also have been saturated with ferrous carbonate. Furthermore, it seems hardly reasonable to imagine that oxidation of the carbonate in the solution, and the alteration of the oxide back to carbonate, could take place close together.

The preponderance of ferrous carbonate over calcic and magnesic carbonate in the cherty carbonates of the Helen formation may be explained by the importance action exerted by these salts on ferrous sulphate. This action depends on the greater affinity which magnesia and lime possess for sulphuric acid than for carbonic acid, and on the instability of ferrous sulphate. These reactions may be thus expressed·

$$FeSO_4+CaCO_3=CaSO_4+FeCO_3$$
$$FeSO_4+MgCO_3=MgSO_4+FeCO_3$$

Calcic carbonate has a stronger affinity for sulphuric acid than magnesic carbon-

ate, and in this way may be found an explanation for the excess of magnesic carbonate over calcic carbonate in the carbonates of the Helen formation; and it is possible that the following reaction may have occurred:

$$MgSO_4 + CaCO_3 = MgCO_3 + CaSO_4$$

The explanation of the non-appearance of $CaSO_4$ (gypsum or anhydrite) is the much greater solubility of this salt than any of the carbonates.

It has been mentioned that the iron-bearing rocks of the Helen formation are in part of mechanical origin. The definitely clastic material consists of the three minerals, quartz, chlorite, and microcline, and there are probably other minerals represented. The grains of the several minerals are all small and, as no pebbles exist, it is presumed that there is no pronounced unconformity between the Helen formation and the rocks beneath it; but there must have been at least a slight break to permit the corrasion of the pre-existing rocks. Quartz is a common mineral in the quartz-porphyry schists of the Lower Huronian, and from these may have been derived the supply of that mineral in the Helen formation. Similarly, hornblende, augite and biotite occur in the earlier rocks. From these the chlorite may be a product of decomposition. The occurrence of microcline is not so easily explained. Microcline, so far as known, is not now recognizable in either the felsitic schists of the quartz-porphyry schists — the only acid rocks of the Helen formation in which it might be expected to occur. It is quite possible that all the microcline may have disappeared in the sericitization of these schists, though this seems rather a contradictory suggestion to make of compact igneous material when it has withstood alteration fairly well as clastic material probably as fully exposed to surface and deep-seated metamorphism. Microcline is common in the post-Huronian acid eruptives, but they are of course later than the Helen formation. However, the occurrence of abundant microcline may indicate the presence of acid rocks in or below the Lower Huronian other than the quartz porphyry and felsite schists. The post-Huronian acid eruptives may be the re-fused equivalents of these earlier acid rocks.

Pure quartzites, that is, rocks consisting chiefly of quartz fragments, are very rare in Michipicoten, and with the clastic material there is always more or less material of chemical precipitation, and we have cherty quartzites, sideritic quartzites, etc. Similarly rocks consisting chiefly of microcline or other feldspars are never found in definite connection with the Helen formation, and though those which contain a great deal of microcline are spoken of as sideritic or cherty arkoses, it would perhaps be more correct to call them felspathic siderites or cherts. As already mentioned in connection with the sedimentary rocks of the Michipicoten schists, true arkoses are found on Reed lake, but there is no reason to suppose that these are of the Helen formation.

Most of the chert formed would be deposited free, forming sometimes beds of pure chert; again when mixed with carbonate, cherty carbonate; and when with pyrites, pyritous chert. From a subsequent alteration of these have resulted the other rocks of the iron range. It is possible that part of the banded chert is an original rock made up of ferric oxide, derived from the oxidation of ferrous carbonate at the surface interbanded with chert, and this suggestion seems to be supported by the record of borings at the Helen mine. These pass through alternate layers of cherty carbonate and of banded chert.

The mode of origin of the amphibolitic schists of the iron formation has already been briefly intimated. They are the result of either contact or dynamic metamorphism. The banded jaspers are supposed to be the product of deep-seated metamorphism, and in the Helen iron formation apparently occupy stratigraphically an inferior position. They result from the banded cherts by dehydration of the hydrous iron oxide. Originally formed at the surface as ordinary ferruginous chert, by sedimentation in bands, when deeply buried and folded the hydrous iron oxides were dehydrated and changed to hematite, which gave to the iron its specular character and altered the rusty ferruginous chert to crimson jasper. From still further changes

to the sideritic chert, banded cherts and jaspers, have resulted the deposits of hematite. This is too large a subject to be considered here, but briefly it is a process of direct oxidation of the carbonate and partly of enrichment due to the action of descending, and to a less extent, of ascending waters acting upon the iron sediments.

Deposits of pyrites and of pyrrhotite occur at several points within the area with which this report deals. As already mentioned, they are supposed to result from the reduction of the sulphate by carbonaceous material, which is found commonly in the phyllites of the iron formation. Apparently at these places the sulphate salt was more common than the carbonate salt in solution; or it is possible the segregation of the sulphide may be the result of enrichment due to metasomatic change subsequent to the deposition of the rock.

It was noticed that great quantities of the iron sediment were strongly magnetic, particularly the banded cherts, and even more so the banded jaspers and amphibolitic schists. It may be judged from this that the magnetite is a product of advanced metamorphism and is probably formed by the deoxidation of hematite or limonite in a deep-seated zone or along or near the contact of an igneous intrusion. The few small deposits of magnetite in Michipicoten have always been found where one or other of these phenomena has been operative. It is possible that magnetite may also be formed by the direct oxidation of ferrous carbonate, as at one point at least on the range just west of Iron lake, siderite and magnetite were found in intimate connection close to the edge of a diabase dike.

EXTENT OF THE HELEN FORMATION

Formerly the Helen Formation was of extensive distribution, and though at present much of it remains, still by far the greatest part has been removed by inter-Huronian erosion and to a much greater degree by the long continued post-Huronian erosion. It has been mentioned that the rocks of the western Michipicoten range are much less complexly folded than those of the northern range. For this reason, in part the removal by denudation of the formerly existing iron-bearing rocks has produced a different character of outcrop in the case of the western as opposed to the northern range. The western range now appears as several generally very narrow bands lying parallel and very close together in an iron-bearing belt in some places almost half a mile in width. Phyllites or schists of igneous origin separate the narrow bands of magnetic cherts and other ferruginous rocks from each other, within the iron-bearing belt. In the northern range, speaking somewhat roughly, the outcrops of the formation make up two more or less widely separated bands, running each in a general way east and west. These bands represent the opposite limbs of the complex synclinorium already mentioned in connection with the northern Michipicoten Huronian area. Between the two bands lie the thick beds of the Doré formation. In the west of the area only the northern limb appears prominently.

Northern Band of Northern Range

The northern band of the northern range extends brokenly from the eastern branch of the Pucaswa on the west to the McKinnon tote road near the Magpie river on the east. For some three miles west of Bole lake narrow outcrops of banded and very magnetic chert can be seen in the green schists, but these are not of economic importance, seldom if ever exceeding twelve yards in width. Eastward from Bole lake the really wide band commences, and from this point to the end of McDougall promontory at Red Pine point for a distance of about four miles there is a continuous outcrop of the Helen formation occurring in a series of high cliffs facing south. At Red Pine point the iron range disappears below the waters of Iron lake, and does not reappear until about one mile west of Clear Water pond, and rather more than

two hundred yards north of Iron creek. Here two parallel bands run about two hundred yards apart and are supposed to be the opposite limbs of a syncline of the second or third order, and both part of the northern band. These sub-bands are continuous for over half a mile, and on them is staked the Katossin claim hereafter described. Some three-quarters of a mile along the strike from the place where they die out, one or other reappears at a point about one-quarter of a mile north of Pitch Pine lake, and thence is continued eastward as an unbroken band almost to the Dog river. East of the Dog river is a narrow band of rusty pyritous chert less than a quarter of a mile long and of no economic importance. Farther east, north of the marsh, on the portages between the Dog river and the Frances mine, the formation once more shows up, appearing first as narrow lenses in nacreous much-sheared quartz-porphyry schist, and afterwards as several closely parallel bands. These are continuous almost to the shores of Paint lake, where the formation is cut by the high granitic boss forming mount Raymond. From this point for some distance the tracing out of the iron-bearing sediments is a matter of extreme difficulty, it being often almost impossible to distinguish between schists of igneous origin and those formed from the sediments due to the metamorphic action of neighboring granitic intrusives. Roughly, however, the wide band runs directly north from mount Raymond, bordered to east and west by granite or quartz-porphyry. About one-half a mile north of Paint lake the strike, if so complicated and brecciated a structure can be said to exhibit strike, changes to north 60° west, and the band assumes that direction. Beyond this point the few isolated outcrops of chert and schists, both profoundly altered, being cut by both acid and basic eruptives, were insufficient to explain the relations existing between the two rocks. The relatively high ridge of hills which extends northward from mount Raymond is broken by many wide deep valleys marking the erosion of former dikes.

Less than one mile and a half in a direction north 20° west from mount Raymond is Morse mountain. On the southern part of this hill chloritic schist alone appears, but the northern part of the hill shows a wide outcrop of banded and rusty chert which continue more or less in a direction north 30° east between Heart mountain and Cushing lake for a distance of about a quarter of a mile, where they disappear in low ground.

Some two hundred yards east of the north end of Heart lake is a narrow band of rusty chert about 650 yards long, running in a general direction north 30° east. To the south this is cut off by basic intrusives which near the contact have metamorphosed the sediments to amphibolitic schists. In this direction it was probably formerly joined to the Morse mountain band. To the north it is cut off by the narrow neck of granite and quartz porphyry which joins the main northern mass of post-Huronian acid eruptives with the smaller Kabenung lake boss. This band is interesting only from a scientific standpoint, as its widest part is only some fifteen yards across.

Opposite the confluence of the Crayfish river with the Dog river, in the thoroughly contorted schists cut in every direction by inclusives, both basic and acidic, occurs a narrow lens of a banded actinolite-magnetite schist which is apparently an altered sediment of the Helen formation. It is only a few yards long and dies out in "tails" in the schists. Some 450 yards west of Narrow lake the formation reappears and is traceable brokenly as far as the northern arm of lake Charlotte. The band is narrow, nowhere exceeding ten yards in width. Changes of strikes are frequent on this band, the vertically standing beds running at south 70° east at the western end of Narrow lake, at about north 70° east at the western end of lake Charlotte, and bending to the former direction farther east. North of this main band several smaller lenses occur in the highly metamorphic schists but they are quite unimportant.

Along the northern shore of East Kabenung lake narrow lenses of magnetic chert first appear in the schists towards the northwest end of the lake. These widen to form the band of Magnetic point, and of the adjoining islands to the east. A few lenses also occur on an island a quarter of a mile still farther east. From this point the next appearance is about twelve miles farther east and along the shore of Evans'

creek, and from two to two and a half miles northeast of Godon lake. Several generally parallel bands occur in this distance of one half mile across the strike, and extend for rather more than a mile in the opposite direction, dying out near the McKinnon tote road.

Southern Band of Northern Range

The southern band of the northern range from its extremely irregular distribution, particularly towards the western end of the area, seems to have suffered greater transverse folding than the northern band. It first[14] appears suddenly as a wide irregular mass of cherts, etc., at the Frances mine. About two miles southwest of the Frances mine a narrow lens of chert appears on the shore of a marshy pond, but this has apparently no connection with the main southern band. Eastward from the Frances mine a wide muskeg swamp stretches to the foot of Brotherton hill—the next outcrop of the Helen formation. From a careful study of the structure of both the Frances hill and of Brotherton hill, I feel confident that all of the iron formation which formerly existed between these two hills has been removed by erosion, and that the low swamp indicates the weathering of the softer green schists below the hard rocks of the iron range. East of Brotherton hill the Helen formation dies out for some miles, to reappear as several generally parallel bands to the east of No-fish bay of Kabenung lake. These bands have a general northeastern direction, and unite in an extraordinary hill at the northeastern end of No-fish bay and on the neck of the peninsula between No-Fish bay and Perry's bay. From this point the united band strikes first in a southeasterly direction, then in an easterly direction, and is continuous to the south of White Water Lily pond.

West of the entrance of Elmo creek into lake Elmo, narrow lenses of black chert are to be seen in the schists. East of the creek these unite to form a decided band of variable width, and of more or less regular strike, in a direction north 80° east, which is continuous for over a mile, then dying out in the tail-like lenses so common in Michipicoten.

East of Leach lake is a wide appearance of the Helen formation. Here three decided bands and many smaller sub-bands appear interstratified with the schists. I have designated these bands by the numbers*1, 2, 3, 4, 5, 6, counting from west to east, from where crossed by the township line—the northern boundary of township 30—and sub-bands A and B, the former a part of band 3, and the latter a part of band 2. Neither of these sub-bands crosses the township boundary line. Band 3 is the most prominent of all. Its branch, sub-band A, dies out just south of the forty and one-half mile post, but soon outcrops once more and is continuous more than half-way across the township, running with a regular strike almost east and west.

For five miles to the southeastward of the point of disappearance of sub-band A no outcrops of the Helen formation were observed. Then at a point less than a quarter of a mile from the eastern shore of Godon lake the iron-bearing rocks again outcrop prominently and run in a narrow broken band southward to the small pond lying east of Pyrrhotite lake and joined to it by a narrows; southeastward from this small pond the band is traceable as a narrow lens, appearing at wide intervals along the exposed western face of the ridge of hills, running to the east of Pyrrhotite lake, lake Marian, Punk lake and Emerald lake.

East of the Magpie are the Eccles lake claims, located in the southwest corner of township 28, and staked on a great many narrow lenses of Helen formation lying within their boundaries. These lenses of iron-bearing rocks may be said to mark the link between the northern and eastern Michipicoten iron ranges. They were somewhat hurriedly examined by the writer, and will be discussed in connection with this report. Though from a geographical standpoint, being east of the Magpie river, they

[14] A very narrow lens was found about three miles farther west, but it is of no economic value.

may be said to belong with the eastern iron range, still they are supposed to represent the continuation of the iron-bearing rocks on the opposite side of the Magpie, and hence are to be connected geologically with the northern range as well.

The Western Range

The western Michipicoten iron range, or the Pucaswa section, may be said to start on the Lake Superior shore about three and a half miles southeast of the mouth of the Pucaswa river. At this point some ten narrow bands of iron formation appear interstratified with schists. They are traceable for only a few yards back from the lake shore, and are lost beneath a sand-plain which extends northward almost to the banks of the Pucaswa river. Some three and a half miles slightly east of north of this first appearance of the western range is the second outcrop on Laird's claim. Here several narrow bands appear in the schists for rather over a quarter of a mile across the strike, and run for about the same distance along the strike. Less than half a mile farther east the bands reappear, not far north of the Julia river, and are brokenly continuous for a little over a mile. From this point where they die out to the western end of David's lakes is about three miles, and during this distance a few short lenses outcrop, but they are narrow and unimportant and extend for only a few yards above the generally level and little broken country.

David's lakes are situated some six miles north of Red Sucker harbor, and just north of the headwaters of Pipe river, although they themselves empty to the eastern branch of the Pucaswa, south of which they lie at a distance of rather less than a mile. Just north of David's lakes and extending about one and three-quarter miles to the northeastward is an iron-bearing horizon. The banded cherts which compose this horizon, are cut off to the eastward by the intrusive granite and disappear to the westward in low ground. On the bands of iron formation north of David's lakes are staked the David Katossin claims.

About four miles southeast of the point where the banded cherts of the David Katossin claims are cut off by the granite, they re-appear on the eastern limit of the eruptive rock to the northwest of Maple lake. From this point several narrow and parallel bands run north of Maple lake, and extend in a somewhat broken manner to and north of Lost lake to the Floating Heart creek. The band crosses Floating Heart creek and continues eastward to Cameron lake. On the eastern side of Cameron lake only a few scattered and very narrow lenses are visible. From Maple lake to Lost lake the western range is much drift-covered, and solid rocks, particularly those of the Helen formation, do not outcrop prominently, so that it is practically impossible to study the rocks of this section in any detail.

For some seven miles in a direction somewhat south of east of Cameron lake, granitic rocks occupy much of the surface of the country, and intervene between two patches of Huronian. Not far from the eastern margin of the granite, rocks of the Helen formation appear near the headwaters of Fall creek and at about two miles from the Lake Superior shore. They occur in disconnected scattered lenses which may be traced southward to the Lake Superior shore, where they outcrop a short distance west of the mouth of Fall creek.

About a mile and a half north of the mouth of the Pucaswa is the Edey claim staked on iron-bearing rocks which have no structural resemblance to the rocks of the western Michipicoten range proper, but which geographically belong with the western Huronian area.

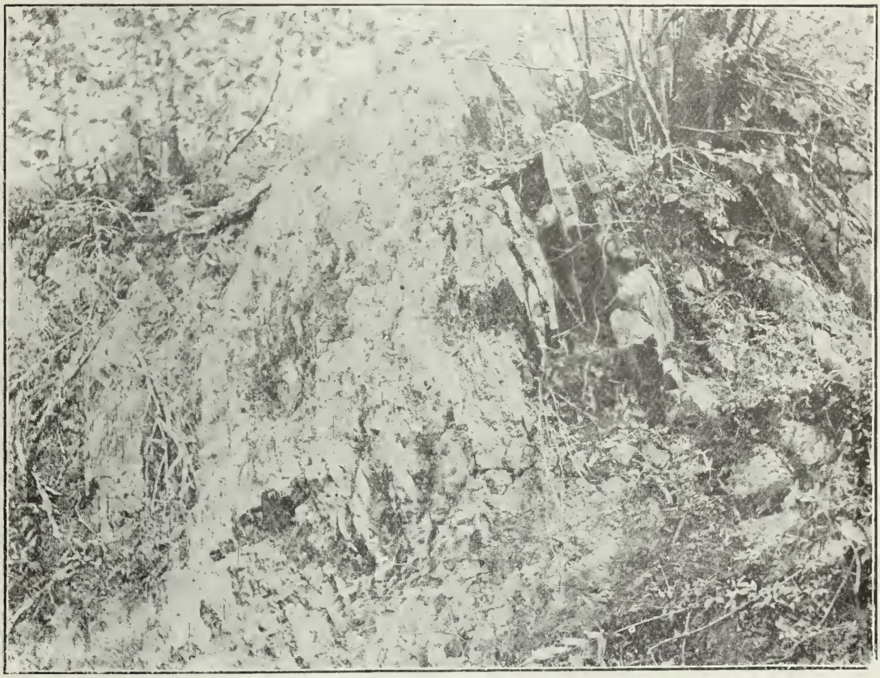
Some ten miles in a direction north 20° east of the mouth of the Pucaswa is the Lorne prospect of impure magnetite, which occurs near the shores of McDougall's lake in highly metamorphic schists, a very small inlier of Lower Huronian rocks within granite. These interesting rocks have no visible connection with either the western or northern Michipicoten Huronian areas, but I am of the opinion that they are to be connected with the latter, since they are almost on the line of the strike of the narrow belt of Huronian rocks which extend south of west from Iron lake.

The bands of richly ferruginous cherts which appear on the Gros Cap peninsula near Michipicoten harbor, and which belong with the eastern range, may be the continuation of the banded cherts of the western range which dip below Lake Superior just west of Fall creek.

SPECIAL AREAS OF IRON FORMATION

Iron Lake

The Iron lake area extends from Bole lake on the west to Red Pine point at the eastern end of MacDougall's promontory. It is the widest and longest continuous band in the district, being over two and a half miles long and having a maximum width of a little over 1,100 feet.



Iron formation, Iron lake.

It appears topographically as a relatively high range of hills of more or less regular angular outline, presenting steep cliffs relieved by talus to the south and more sloping faces to the north, and cut across by frequent valleys which represent eroded dikes or fissures. The band consists of a series of closely compressed south-dipping isoclinal folds, with minor pitches to east and west and major pitch to the east. The direction of pitch of folds of the iron formation is often difficult to discover. Actual pitching troughs or arches were not often observed in the field, and the pitch of the synclines was judged generally by the slight persistent divergence of the strike on the opposing limbs. In a general way the pitch is probably to the west near Bole lake and to the east near Van Evera's lake—certainly to the east (with high angle) near the shacks formerly occupied by the Minnesota Iron Company, and again in the same direction at a point about half way between the shacks and the western end of Minnesota bay (and at an angle of about 45°). From this point it is probably towards the east as far as the diabase dike which runs almost north and south near the foot

of Minnesota bay, and may be from the opposite direction on the opposite side. The outlet of Windigo-Weas lake into Iron lake is along an eroded diabase dike, and from the conditions of jointing seen on either side of this dike, it is presumed that the pitch is away from the dike in opposite directions. To the east of the dike the dip of the jointing planes is to the west, and west of the dike nearly vertical or possibly slightly to the east. Since in joints due to torsion the direction of the jointing plane is roughly perpendicular to the dip of the strata, and since the pitch is a form of dip, it is presumed that the direction of the pitches of the troughs are at right angles to the dips of the jointing planes and hence in the direction named.

The general trend of the Iron lake band is more or less uniform from Bole lake to the Minnesota shacks, the strike being about north 80° east. The Minnesota shacks lie in the valley formed along the eroded plain of a thrust fault. Here the beds turn sharply to the north and then north 65° east, and this general course is maintained to the point where the bands dip below the waters of Iron lake at the end of MacDougall's promontory, though numerous small irregularities and even autoclastic breccias occur. The dip is always to the south at an angle varying from 55° to the vertical.

The Iron lake band is bordered to the south by a narrow layer of quartz-porphyry schist separating it from the Doré conglomerate. This schist seldom outcrops, but its position can easily be followed by the narrow valley which runs parallel to the iron range, and which shows that erosion has eaten through the higher iron formation into the lower schists. At some points near Bole lake the iron range seems to be in almost immediate contact with the conglomerate, as no schist outcrops and the valley reduced to a minimum. To the north of the range, the bordering rocks are as a rule pinkish, greenish or yellowish felsite and quartz-porphyry schists, often silicified or carbonatized, but at one point at least amygdaloidal chlorite schists may be found in close proximity. The quartz-porphyry schist on the north side of the iron formation is lithologically almost identical with that on the south side, and it is presumed that they represent the opposite limbs of a synclinorium.

Dikes of diabase traverse the iron range at four points. One running in a direction south 70° east cuts the sediments along the north shore of Bole lake. A second running about southeast, outcrops prominently as a west facing cliff just west of the Minnesota shacks. A third with a course north and south is exposed near the foot of Minnesota bay. It appears only towards the north of the iron range, but its course southward is marked by the path of a small stream. A fourth dike is the one which follows the outlet of Windigo-Weas lake, seen in numerous outcrops to run about south 15° west.

Dimensions and Relationships of Band

The range has a width of some 460 feet on the side east of the dike, at Bole lake, of about 600 feet (possibly more) at a point about one-half mile west of the Minnesota shacks. Eastward from the fault line it gradually widens, and north from the foot of Minnesota bay has a width of 1,050 feet. From this point the southernmost part of the band disappears below the waters of Iron lake, and the northern becomes intermixed with phyllites and schists. To the west of Windigo-Weas lake, and between that body of water and the main lake, the outcrop has a width of some 400 feet above water, and when it disappears altogether below the water at McDougall's promontory it has a width of 250 feet. North of the main band and running approximately parallel with it are several narrow bands, more or less persistent for a few hundred yards. These bands are the pinched-in remnants of synclines of a higher order than the main band, with which they were formerly connected before erosion had proceeded so far as it has at present. The most prominent of these is at Windigo Bones point, where the width is about fifty feet.

Lithologically, practically all the rocks of the Michipicoten iron range are represented at Iron lake. The prevailing type is a somewhat impoverished, banded chert, almost always magnetic. Towards the northern part of the range are the less weathered varieties, and true banded jaspers showing distinct separated layers of jasper and magnetite are observed in many places along this face. On the exposed southern face of the cliff to the west of Iron lake, the iron-bearing rocks are much decomposed, and in the valley below, particularly near the edge of the Doré conglomerate, consist of rusty granular or sandstone chert.

The much jointed cherts facing the water along the north shore of Minnesota bay are extremely sideritic, whereas their opposite slopes are often jaspyllitic. Coarse-grained chloritic siderites, in intimate connection with highly magnetic banded jaspers, occupy an adjoining position just west of the third dike described above, and their relations may possibly indicate that the latter is a metamorphic product of the former. The sedimentary origin of these particular coarse-grained siderites, interbanded, with the iron formation seems questionable. They may simply represent the extreme phase of carbonization of the much altered intrusive igneous rocks—dolorites or diabases which have been already described as consisting in large part of siderite or other carbonates.

Associated with the cherty ferruginous rocks phyllites occur in several places—notably in the valley between Windigo Bones point and Red Pine point, and the cherty siderites along McDougall's promontory contain so much chlorite or microcline that they become sideritic slates or arkoses.

The numerous chloritic sideritic schists interbanded with the iron formation are, I think, all of igneous origin, though some of the narrower sheets towards the north of the range may be sedimentary. These sheets are limited almost entirely to McDougall's promontory and just west of it, where by their occurrence the value of the iron formation is greatly deteriorated by lessening the amount of rock from which ferruginous material can be drawn and by preventing by their imperviousness the lateral flow of meteoric waters, since both free circulation and abundant iron formation are requisite for the development of a large ore body.

The metamorphic influence of the smaller intrusive dikes, etc., upon the iron formation is not pronounced. The contact phenomena are comparatively slight, being shown only by the greater amount of magnetite close to the dike than at some distance from it. On the other hand, the propyllitization of the narrow dikes by solutions derived from the iron formation is general, and will be discussed later. The wide boss of magnetic diorite existing north of the Algoma Commercial Company's shacks on Minnesota bay has greatly altered the rocks into which it has been intruded, which for over a quarter of a mile north of the boss strongly deflect the magnetic needle. The altered rocks consist chiefly of magnetic epidote schists, with probably some magnetite amphibole schists. They are apparently often altered sideritic slates, though much of them may be altered igneous schists, and only a comparatively small portion have been proved to be undoubtedly sedimentary. The origin of most of these magnetite bearing rocks is difficult to decide definitely, owing to the extreme degree of metamorphism and the somewhat confused field relations.

South of Van Evera's lake and near Bole lake the banded cherts are highly ferruginous. In the ferruginous cherts south of Van Evera's lake occur small pockets six or seven inches wide of a hydrated hematite. On these, test pits were sunk by the Minnesota Iron Company, but the iron improved neither in quantity nor quality in descending. A great deal of test-pitting and stripping has also been carried out at Bole lake, but these operations were not conducted along the contact with the overlying formation, apparently the most likely spot at this locality for the occurrence of an ore body.

Ore Showings

Along the range between the Minnesota shacks and Iron lake a considerable amount of stripping has been done, much test-pitting carried out, three tunnels run and one shaft sunk on small pockets of ore visible on the surface.

The entrance of the first tunnel is about 200 feet northeast of the shacks. The tunnel runs to the northeastward into the pronounced west facing cliff. At the entrance to the tunnel soft bluish hematite, much mixed with chert, appears on the walls. About seventy-five feet higher up the hill, and some fifty feet or more farther east, is a second tunnel which enters the hill in a southeasterly direction, and then turns northeastward. The ore showing here is of better quality than at the lower tunnel, and consists of bluish soft hematite, with specks of quartz. The ore body apparently has a vertical thickness of at least twelve feet, and becomes less ferruginous and merges into the cherty rocks above, which contain comparatively little iron. Downward the face of the hill is covered with talus and the extent of the ore body in that direction is not traceable. I understand from Mr. Robert Murray, formerly in charge of the exploration work carried on at Iron lake, that the ore became more silicious away from the outcrop. The third tunnel is excavated into the hill at a point about 250 yards east of the other two, just north of the trail, which connects the Minnesota shacks with Minnesota bay. It was carried into the hill for a distance of 160 feet. Pockets of good soft ore (hematite) occur for this distance, but are much mixed with chert. The tunnel has a height of eight feet above the shelving bank, and a width of about six feet, and these dimensions may be said to mark the limits of the ore, at least above ground. Above the ore and standing in marked contrast is an area of almost pure white, very quartzose chert, showing no banding. The ore itself is soft reddish hematite, and with some botryoidal and rusty hydrous hematite.

Analyses were made of various specimens of ore, and of enclosing iron-bearing rocks from the Iron lake area. The results of the analyses follow below. Number 1 is an iron ore from the upper tunnel (second tunnel above described), and may be said to represent one of the relatively rich ores of this locality. It will be seen that as far as sulphur and phosphorus are concerned, the ore is of Bessemer quality, but it is low in iron content. However, it is a soft ore, and if it existed in quantity, would certainly be marketable. Number 2 is a soft and often very red limonite from the tunnel on the trail between Minnesota bay and the shacks (third tunnel above described). Number 3 is a soft ore jasper from the same tunnel. In the field the rock is very irregularly banded, and consists of pinkish chert gathered in irregular areas with impure purplish chert and streams of rich dark red hematite. Number 4 is a jaspyllite from McDougall's promontory, consisting of interbanded pinkish, somewhat crystalline chert, reddish very silicious ore and streaks of specular hematite. Number 5 is a pyritous cherty siderite of an opalescent bluish gray color, from flank of hill facing Minnesota bay. Number 6 is much the same only darker in color, from Red Pine point, while number 7 is from a boulder of cherty siderite found in the drift on the portage between Iron lake and Minnesota bay.

	Fe.	P.	S.
No. 1	59.52	.04	.02
" 2	54.76	.035	.02
" 3	36.03	—	—
" 4	21.14	—	—

——	$Si\,O_2$	Fe O	$Fe_2\,O_3$	Ca O	Mg O	$C\,O_2$	S
No. 5	84.76	6.82	2.80	trace.	.28	3.75	.70
No. 6	81.86	9.97	1.53	trace.	.30	5.49	.63
No. 7	62.78	17.87	5.17	trace.	1.42	12.11	....

A Promising Prospect

It has been a matter of general comment among geologists and mining men generally on the south shore of Lake Superior where large ore bodies have long been developed, that these bodies occur in places where certain definite geological conditions have been realized. These conditions have been enlarged upon by various geologists,[15] and it is unnecessary for me to more than mention them here. The presence of an impervious basin beneath the ore formed either by igneous schist, sedimentary slate or eruptive rock, is a striking feature generally observed in connection with all large ore bodies in regions of similar geological conditions as exist in Michipicoten. This basin may be a pitching trough sloping from two directions to a common centre, formed by transverse folding of longitudinal folds, or this larger trough may be divided into several smaller troughs by transverse dikes. Contact planes, much fractured iron formation giving free passage of circulating waters, a wide outcrop of iron formation, and in general a much decomposed and deferruginized surface outcrop, are generally also connected with iron ore deposits of this sort, when of economic importance.

It will be seen that at Iron lake we have ideal conditions for the development of ore bodies. *First,* an abundant iron-bearing formation. *Second,* pitching troughs on an impervious basement of various green schists. *Third,* numerous secondary structures developed, faulting, jointing, brecciation, etc., allowing free circulation of iron-bearing solutions and permitting the enrichment of the ore bodies. Large quantities of ore are certainly not found at the surface, and if they exist, as seems probable, they are either beneath the rock surface or else are covered by sand or other drift or talus. As the truncated isoclinal folds dip to the south, it would appear preferable to conduct exploration for ore bodies from that side. The cross diabase dikes act as barriers to the iron-bearing waters and cause the depositions of ore where the trough pitches towards the dike, hence there would be near the dike a position on the south side which would seem especially favorable. There are many such positions which combine these favorable conditions at Iron lake.

The Iron lake range is on the whole an exceedingly desirable and likely prospect, and there is apparently no reason why ore bodies should not be found there.

The Katossin Claims

The bands of the Helen formation on which the Katossin claims are staked, are situated north of Iron creek and of Clearwater pond. It has already been mentioned that they are continuous for about one-half mile, and that they represent the opposite limbs of a synclinal fold of a second or third order. At the surface neither band is of great width, seldom exceeding twenty-five yards across. They are both complexly anticlinal in structure, and the north band, at least, shows green schists overlying on both sides. From this it is presumed that the schist occupies the top of the trough between the two bands, though comparatively few outcrops either of schist or of Helen formation appear above the sand-plain, and it is difficult to make sure on this point. The extent of the iron formation, particularly adjoining the north band, was traced by magnetic observation, and was found to continue for thirty or forty yards at least on either side beneath the schists. Moreover the different outcrops were connected in the same way along the line of strike, although the north band was not actually joined to the south one by this means.

Lithologically, the north band consists chiefly of pyritous, very magnetic, cherts, often rusty and impoverished, and of interbanded crimson jasper and bluish magnetite or specular hematite. The latter, which may be called jaspyllites, sometimes contain so much iron ore as practically to be considered an iron ore. The south band is made up of much the same material, though rather more decomposed and less jasper-like.

[15] See "The Exploration of the Ontario Iron Ranges," by A. B. Willmott, Journal of the Canadian Mining Institute, Vol. VII, pp. 257-261.

Analyses were made of several specimens from the Katossin claim, all from the north band, and the results are given below. Number 8 and Number 9 are rich magnetic cherts, and Number 10 is one of the very rich jaspyllites.

	Fe.	S.	P.
No. 8....	43.17	.05	.093
" 9	40.39	.06	.04
" 10....	58.48	.02	.035

The general strike of both the north and south bands is north 85° east, and the dip both to north and south, though generally the latter.

Basic dikes certainly traverse the south band and probably the north one also. The troughs pitch sometimes at a high angle, sometimes at a very low angle to the eastward, so that closed pitching troughs favorable to ore-deposition are common, and secondary shearing along the bedding planes has produced micaceous specular hematite. Schists usually of the fine-grained chloritic type, are found freely pinched-in with the iron sediments, and it is not always possible to tell the relative age of the iron formation and of the schists It is also impossible to even attempt an estimate of the thickness of the beds. The minimum may be set at ten feet, and is probably many times greater.

Katossin claim, Iron river, showing anticlinal strata.

On the whole from surface examinations the Katossin claims do not seem at first sight a promising prospect, but when it is remembered that the entire trough between the bands is probably occupied beneath the sand and schist (certainly not of great depth) by an unknown and perhaps great thickness of iron sediments, the economic possibilities of the claims seem more favorable.

West of the Dog River

About one-quarter of a mile north of the east end of Pitch Pine lake beds of Helen formation appear above the general low ground, and are interruptedly continuous almost to the Dog river, a distance of about three-quarters of a mile. The

ferruginous rocks form a comparatively narrow band seldom, if ever, exceeding thirty-five yards in width, bordered to the north by soft chloritic, sometimes nacreous felsitic or quartz-porphyry schists, and to the south by black phyllites or quartz porphyry schist.

The exact structure of the band was unidentifiable, but apparently it consists of a series of very closely compressed isoclinals. The strike varies from north 65° west towards the eastern end of the band to north 85° west at the opposite end. The dip is generally vertical, but is occasionally to the south.

The rocks consist entirely of rusty banded chert, often pyritous and occasionally magnetic. The quartz-porphyries associated with and bordering the iron formation are greatly silicified, and in places carbonatized. These altered schists have often a strong lithological resemblance to the Helen sediments. The phyllites which appear along the south side of the band at one or two points, are black, fine-grained, and very regularly crenately-banded.

Paint Creek and Mount Raymond

The Paint Creek band starts as a number of narrow lenses in the mashed quartz-porphyry north of the marsh which lies just east of the portage from the Frances mine to Paint lake, and is continuous as one larger band and several smaller unimportant sub-bands almost to Paint lake, a distance of over a mile, where it is cut by the granite boss forming mount Raymond. Beyond mount Raymond it bends sharply to the northward and may be traced as one wide mass for over half a mile. The range appears as a low line of hills to the west gradually rising to mount Raymond, which has an altitude of about three hundred feet, then dropping slowly towards the north. The iron formation west of mount Raymond will be described as the Paint Creek band, while north of mount Raymond will be considered as the mount Raymond band.

The Paint Creek beds have a maximum width towards the west of one hundred and sixty feet, and are generally much narrower, but to the eastward they rapidly widen and have near mount Raymond a width of over seven hundred feet. Towards the west, quartz-porphyry schist of the underlying green schists strongly predominates over the iron-bearing rocks. The latter appear at intervals within the schists only as narrow, shallow outcrops, which represent the eroded remnants of former deep synclines. As the range increases in height to the east, the quartz porphyry schist becomes less important in the belt, and finally dies out altogether.

The strike of the range varies from south 80° west on the west to north 80° west or the east. The dip of the beds varies slightly from the vertical both to north and south, and the pitch is probably for most of the length of the trough to the east though from the relations of the parallel range at the Frances mine it would seem to be to the west for at least part of the distance. Three visible cross dikes of diabase traverse the range, and as mentioned above, a wide boss of granite cuts it off near Paint lake.

The prevailing type of rock is a rusty impoverished granular or banded chert, often pyritous, occasionally sideritic, and sometimes magnetic. The eruptive granite of mount Raymond has altered the Helen sediments both physically and chemically. The beds have been much contorted and brecciated. The banded ferruginous chert has been changed to magnetite actinolite schist, and magnetite grünerite schist. Small contact metamorphic deposits of very impure magnetite, which contains 21.42 per cent. metallic iron, have been formed near the edge of the boss in the porous iron formation, and a wide quartz vein which is highly pyritous and slightly auriferous, has developed in close proximity. This quartz vein is at least fifty feet wide and probably three hundred yards in length, though this could not be definitely ascertained. It was probably formed by the metasomatic impregnation of the iron sediments by quartz, bearing slightly auriferous pyrites, and probably some other sulphides, brought by hydrothermal waters marking the dying stage of volcanism.

The islands of the western part of Paint lake and the eastern mainland opposite them are composed of hard dense, fine-grained garnetiferous zoisitic schist, resembling a hornfels in the field. It is often rusty, due to the oxidation of the large amount of iron pyrites which it contains. This rock, on account of its megascopical, lithological resemblance to unquestionable clastic sedimentaries and because of the absence of any definite igneous characteristics, when studied microscopically has been considered as a much altered slate, but it is possible that it may be more correctly a highly metamorphosed chloritic schist.

The structure of the complicated mass of rock near mount Raymond is exceedingly difficult to study, owing to the confused nature and scarcity of the outcrops and the extremely thick and tangled forest growth which completely clothes the country in this vicinity.

Ore Possibilities

The low-lying shores of Paint lake just to the south of mount Raymond are covered with a deposit of mossy peat, two to three feet thick, beneath which is a thin layer of bog iron ore formed from the leaching of the ferruginous sediments on the hills above. The deposit is too small to be of much economic value. The ore contains 54.6 per cent. of metallic iron, .08 per cent of sulphur, and .016 per cent. of phosphorus.

It is possible that a large ore body may exist to the south and west of the granitic boss of mount Raymond, but I do not think so, as the iron sediments are mostly of the altered character upon which meteoric waters do not easily act to allow the formation of a large ore-body. Westward in the narrower part of the trough there is not a sufficient thickness of iron formation left after the extensive sub-aerial denudation to have ever had an ore-body beneath it.

No part of the Helen iron formation in northern Michipicoten is more difficult to study, and yet more interesting in its field relations than that part of it immediately north of mount Raymond. As has been explained, mount Raymond is a wide, intrusive granite, and quartz-porphyry granite boss, and this intrusive granite also borders the iron range both to east and west. The influence which this enormous intrusion has had on the surrounding rock is most profound, and is even more pronounced than south and west of mount Raymond.

These rocks have been so intensely corrugated and even brecciated that their former bedding planes have been entirely lost or rendered impossible of recognition. The strike of the beds, if such it can be called, or more correctly the trend of the range, is extremely irregular and is always changing. Roughly, it is almost north for about 600 yards from mount Raymond, then northwest for 200 or 300 yards. Beyond this point the formation is impossible to follow, partly from the thick nature of the forest growth and the large amount of fallen timber, and partly from the scarcity of reliable outcrops. It is possible that the greatest part of the range is covered by more recent schists. The dip is decidedly uncertain, but is generally vertical, sometimes with a slight inclination to the east.

The whole appears to be a compressed compound synclinal fold pitching to the north, as judged from the really few evidences in the field. The width is for the most part great, being rather over 640 feet for the first 600 yards. Beyond this point the width of the much drift-covered band could nowhere be accurately ascertained.

Wide greenstone and quartz-porphyry dikes cross the belt towards its northern limit, and may have acted as barriers to north-flowing iron-bearing solutions, but the nature of the rock, particularly to the south near mount Raymond, being resistant to the attack of the weathering agencies, is prohibitive to the production of an extensive ore-body. While this does not apply so much to the northern part, it is at least an important factor in its consideration.

Morse Mountain

Morse mountain is an irregular shaped hill some 200 feet in height lying about one-quarter of a mile southeast from Heart mountain and rather a greater distance southwest of Cushing lake. Outcrops of solid rock on its southeastern, southern and western faces are entirely of a soft chloritic schist, and on its northwestern face of Helen iron sediments. The summit of the hill is almost wholly drift-covered, the few outcrops shown being small and unsatisfactory. Towards the northwest side these seem to be mostly of rusty chert, and towards the opposite side of chlorite schist. From the northwestern corner of the hill a gradually dropping tongue-like ridge stretches to the northeast between Heart mountain (from which it is separated by a deep valley) and Cushing lake.

The northwestern face of the hill shows the Helen formation outcropping for nearly a quarter of a mile across the strike with three narrow sheets of a granitic porphyry intercalated. On the opposite side of the hill where the green schist outcrops, there is only one sheet of porphyry seen. The tongue-like hill is, close to Morse mountain, composed entirely of rock of the iron-bearing foundation, but at some 500 yards along the strike this dies out in "tails" of chert in the schist.

There are three ways of explaining the rather strange field relations. First, that it is a pinched-in synclinal fold or series of folds younger than the enclosing schists; or second, that it is a southerly pitching synclinal fold or series of folds, in which the chloritic schists to the south are younger than the iron formation, and the latter in turn younger than the schist in which it dies out to the north; or third, that it is a northerly pitching trough with exactly the opposite relations. The second explanation seems to be much the most likely on account of the rather sudden appearance of the iron formation on top of the hill and on account of the tail-like disappearance to the north. However, this is inadequate proof and needs substantiation by further evidence.

The iron-bearing rocks of Morse mountain consist of rusty granular chert and of more or less ferruginous banded cherts, both much impoverished and weathered. The intrusives of Morse mountain are all of the granite-porphyry type, intruded parallel to the dip of the beds through the line of weakness at the base of the isoclinal folds.

Morse mountain has in its favor as a prospect the widest continuous outcrop of Helen iron formation exposed in the northern part of Michipicoten, with ferruginous though now much impoverished rocks, upon which surface water would easily act, and in places a brecciated structure allowing free circulation.

East of Heart Lake

The narrow belt of iron range rocks which occurs just east of Heart lake shows some interesting metamorphic changes. The belt is apparently the small pinched-in truncated remnant of a former deep synclinal trough, which has a general strike of north 30° east, with variations to north 70° east, and to almost north and a prevailing southeasterly or easterly dip of 65° to 85° or even vertical.

The band which has an average width of about forty feet, is terminated to the southward by a large, fine-grained greenstone boss, and to the northward by a portion of the quartz-porphyry edge of the great post-Huronian acid eruptive mass of northern Michipicoten.

Lithologically, away from the influence of the intrusions the rocks consist chiefly of rusted banded chert, and at one point a very small deposit of bog ore exists in a valley between two knobs of iron formation. Near both the quartz porphyry and greenstone the banded cherts are changed by contact metamorphism. The greenstone produces a coarse-grained banded magnetite-hornblende schist, and the quartz-porphyry a somewhat fine-grained hornblende schist.

North of Narrow Lake and Lake Charlotte

Very similar alterations of the iron formation to those east of Heart lake may be seen in the several narrow parallel bands of iron formation which run along the northern shore of Narrow lake and lake Charlotte, the principal band forming in great part the face of the cliff which rises abruptly along the northern shore of the two lakes and is continuous as the northern edge of the valley which connects them. This main band, though never more than fifty feet wide and generally much less, is more or less continuous all the way from a point about half-way between the Dog river and Narrow lake to the northern bay of lake Charlotte, whereas the smaller bands are mere lenses continuous for only a few feet. Structurally they consist of closely plicated, compressed synclinals of almost vertical dip, and with a fairly regular general but very devious and erratic local strike.

The bands run roughly parallel to the contact of the Lower Huronian series with the post-Huronian granites and rather more than a quarter of a mile from it. South of the actual contact with the unbroken mass of post-Huronian acid eruptives numerous narrow sheets of quartz-porphyry and felsite are intruded parallel to the foliation of the schists, and the bedding planes of the iron formation. Besides these sheets of acid eruptives, basic greenstone dikes traverse the range at various points. Their metamorphic effect is less pronounced than that of the quartz porphyries and felsites. By far the greatest part of the iron formation has been more or less thoroughly changed. Sometimes interbanded black or white cherts are seen, or very rusty re-crystallized cherts, but the commonest type is a more or less amphibolitized schist. This rock, which consists chiefly of hornblende, epidote and quartz, is remarkable in containing very little magnetite or even none at all. Presuming that all the minerals of this rock are authigenous, it may be supposed that this hornblende-epidote schist resulted from the metamorphism of a carbonate, rich in lime and magnesia and containing comparatively little iron, with probably some clastic chlorite.

The chloritic schist adjoining the iron formation has also undergone great change, being converted to epidotic and micaceous schist. The boundaries of the metamorphic aureole are exceedingly irregular, sometimes rocks near to the intrusive granite being practically unmodified, while others more remote have suffered complete alteration.

Magnetic Point

Magnetic point on the north shore of East Kabenung lake is a short bean-shaped strip of land connected with the mainland by a narrow neck. Along the exposed southern face of the point runs a line of low cliffs composed of the Helen sediments. The northern face of the ferruginous band is for the most part drift-covered, but in a few places soft phyllitic schists (very probably fragmental) outcrop at a distance of about thirty yards back from the water, giving a maximum width to the belt of at least thirty yards. Still farther north on the mainland only a few small exposures of solid rock are visible, and these are mostly of schist containing narrow bands of magnetic chert. In taking our magnetic readings while traversing the bands the compass showed a phenomenal deviation irregularly both to east and west for over a quarter of a mile north of the water. It may be presumed that lenses at least of iron formation occur within the schists for this distance, though the surface covering of clay and moss precluded actual observation.

The Magnetic point belt outcrops for some two hundred and twenty-five yards along the point itself, and appears on a small island just off the shore and on several adjoining islets still farther east. The bands are a continuation of others occurring in schists and phyllites for over one hundred yards across the strike on the mainland to the west.

The iron-bearing rocks of Magnetic point are composed almost entirely of magnetite-grünerite schist. Sometimes this may consist of wide lenses of a somewhat

magnetic granular chert always containing a few needles of grünerite, and but slightly interbanded layers of sparkling coarsely crystalline magnetite and light yellowish gray-green grünerite, and finally of bands three to four inches wide of almost pure magnetite. Sometimes the magnetite-grünerite schist contains so much magnetite, especially where the wider layers of magnetite occur, that it is practically an iron ore. The beds of iron formation at Magnetic point lie quite one-half mile south of the main mass of intrusive granite, and it is unlikely that this caused the pronounced metamorphism of the iron sediments. This great transformation may be partly due to the intrusions of basic igneous rocks which at least occur, though to what extent is not known, but it is probably mainly the result of the intense dynamic strain which the rocks in the immediate vicinity have undergone.

Analyses were made for iron, etc., of several specimens of the iron-bearing rocks from Magnetic point. Number 11 is a specimen of a highly magnetic grünerite schist, and Number 12 of a coarsely crystalline magnetite from one of the narrow bands above described.

	Fe.	S.	P.
No. 11....	43.35	.009	.073
" 12..	64.31		

The strike is decidedly irregular, the beds being often brecciated. The dip is towards the south at an angle of 75° to 85°. Magnetic point is probably at about the centre of a crumpled synclinal fold, towards which the troughs pitch from either side. The narrow bands of Helen sediments of Magnetic point and of the still narrower lenses farther north, are the bottoms of synclinal folds of a high order—all that remain of what were once parts of a wide belt of iron sediments, probably of great thickness.

Evans Creek Area

The Evans creek area lies close to Evans creek and to the northeast of Godon lake. The area contains two pronounced bands, and possibly a third band of iron formation, which run generally parallel. The more southern of the two pronounced bands forms a decided ridge some two miles northeast of Godon lake, while the more northern band lies about half a mile farther northeast on the northern side of Evans creek. Just south of the creek a few scattered outcrops occur along the flank of a high drift-covered hill. These may represent a separate band or may properly belong to the northern band a few yards distant on the other side of the creek.

The rocks consist of evenly banded highly magnetic chert, and of rusty saccharoidal chert. On the northern band the main outcrop of the iron formation is rather less than a quarter of a mile long and with a maximum width of about 175 feet. It rises as a low hill with abrupt cliffs facing the creek on the southwest side. To the northeast it is bordered by a sand-plain, in which it also disappears to the southeast. To the northwest near where it dips below the sand-plain, it is much mixed with a soft chloritic schist. At three-quarters of a mile farther to the west-northwestward an outcrop of iron formation appears above the sand-plain, and rather less than a mile to the east-southeast a lens of whitish gray and rusty chert occurs in schist. This lens is about forty feet wide, and about four times as long The strike of the band varies from N. 50° W. to N. 80° W., and the dip to the southwest at from 59° to 70°. The band is supposed to be a compressd synclinal fold, but no direct evidence bearing on this point could be obtained. The more southern band is much longer and more continuous than the northern band. It runs somewhat brokenly for more than a mile and a quarter, and is cut off by diabase to the east-southeast, and disappears below the sand-plain at the edge of Evans creek in the opposite direction. Its width is for the most part somewhat uncertain, but at one point at least it is not less than 250 feet across. Structurally and lithologiclly, it may be considered as similar to the northern band.

FRANCES MINE AND NEIGHBORHOOD

The Frances mine range is an irregular-shaped hill presenting steep talus-relieved cliffs to the north, northwest and east, and grading off to the southwest and northeast in long sand-covered slopes.

The only solid rocks appearing in situ on the Frances mine hill are of the Helen iron formation, and these consist of impoverished banded chert, very ferruginous banded chert or soft ore jasper, granular pyritous chert, much oxidized sideritic chert, and few seams of hematite. The total outcrop has a maximum width of 935 feet and a length of 1,375 feet. The rocks are well exposed both naturally and artificially, and comparatively easy of field study.

The iron sediments have been crumpled into a series of closely compressed north dipping isoclinals, each with a decided pitch from east and west, converting them into deep canoe-shaped troughs. These relations have been proved by ample field evidence supplemented by the results of several drill holes. The strike makes many variations from regularity, but its average may be said to be about north 85° west. The dip with one exception is always to the north at a high angle or vertical. By a careful study of the strike all over the hill it was observed that both on the east and west sides the strike of the upturned beds converge towards each other, as would naturlly be expected in synclinal folds. It was also noticed that the angle of convergence was much more open on the west side than on the east, showing a steeper pitch of the troughs on that side of the hill. At the Frances the beds are much contorted, and in many places brecciated—the results of long continued dynamic strain.

Several small and unimportant bodies of iron ore occur on the surface, and were the means of first drawing attention to the Frances. All of these ore-bodies are situated on the top of the hill, and are merely surface deposits. The ore is generally a rich, compact, soft hematite. It is sometimes a blue-black slate ore, and again a hydrous hematite, probably göthite. The value of even these small deposits is lessened by numerous small horses of jaspery chert and geodes of quartz crystal. The larger of these lenses has a length of forty feet, and a greatest width near the middle of nine feet. The rock underlying the iron formation is a soft chloritic schist, as discovered by test pits and drill holes and as exposed at several places to the south and north of Frances mine hill.

We have at the Frances apparently excellent conditions for the formation of a large ore body: to recapitulate, a series of closed north-dipping, canoe-shaped troughs, having a greater pitch from the west than from the east, lying on an impervious basement of green schist, a large amount of iron formation from which to draw material, and this formation brecciated and open to the influence of oxygen and iron-bearing solutions.

From a careful examination of the hill it would seem apparent that the best point at which to carry out prospecting work is on the north side, since the prevailing dip is in that direction, and the best location of a drill hole would be towards the western end of this side, since there is a steeper pitch on that side, and hence the deepest part of the trough containing most of the ore-body might be expected in that position.

During the time the prospect was being worked by the Algoma Commercial Company six drill holes were completed and two more started, the last three being on the north side of the hill. Two of the others were run from the foot of a shaft sunk on one of the small ore lenses already mentioned. I understand that these were drilled; one horizontal to prove the length of the lens of ore, and the other vertical to test its depth. Both soon got out of ore. Had the latter been continued deep enough, it would doubtless have struck ore again, but even if it had, the proof obtained would have been of little value, because it was too far east to have reached the main body of ore, and would not have shown the lateral extent, which in such closely compressed troughs as occur at the Frances is an important feature.

The other three drill holes were carried in either on the southern or eastern side. The drill hole which was completed on the north side of the hill, was successful in locating ore, and I am informed that at a depth of 521 feet a considerable stratum was entered.

Several specimens of iron ore from the small lenses on top of the hill were analyzed, which proved it to be for the most part of fair quality. Number 13 is a soft, bluish red ore; other specimens were of a somewhat harder variety.

	Fe.	S.	P.
No. 13..	62.46	.02	.02

Brotherton Hill

Apparently Brotherton hill is structurally the same as the Frances hill—that is, it consists of a series of closely compressed, canoe-shaped troughs with dip at high angles to the north or almost vertical, and with a general strike of about N. 75° W. The surface outcrops are, however, not nearly so good and those seen are not as favorable as at the Frances, and on the whole Brotherton hill may be considered an inferior prospect compared with the Frances. The total outcrop of the Helen formation is rather over 1,800 feet long, and is at least 900 feet wide at its widest part, but is generally much narrower.

The rocks of the iron formation at Brotherton hill consist chiefly of banded grayish, rusty weathering chert, very rarely highly ferruginous chert, granular pyritous chert, and fine-grained blackish chert. At the southeast corner of the hill and separated from the highest part of it by a cedar swamp, is an outcrop of a peculiar massive highly ferruginous pyritous rock which is probably a phase of the iron formation. On the south side of the hill evenly banded soft grayish phyllites occur close to the cherty rocks. On the north side there are outcrops of chloritic schists, but none in immediate contact with the iron formation.

A wide dike of much altered diabase crosses the hill diagonally, and appears to send sheet-like offshoots in between the beds of iron formation, or at least is in part parallel with the beds rather than traversing them. The widespread presence of this altered diabase materially diminishes the economic possibilities of Brotherton hill:

First, by its impervious nature preventing free circulation of iron-bearing waters.

Second, by its greatly decreasing the amount of iron-bearing formation, from which to draw ferruginous material.

South of Kabenung Lake

The broken bands of iron formation lying to the east of No-Fish bay are almost unworthy of consideration. Roughly speaking there are three narrow bands, never continuous for more than a few hundred yards, and untraceable for much longer distances. The strike is in general N. 30° E., though there are numerous slight departures from this course. From the disparate and irregular distribution of the outcrops taken in comparison with the comparative regularity of the strike and dip, it is presumed that there must be marked and rapid variations in the pitch of the folds to have given the present field relations. All outcrops are apparently in general synclinal, and were evidently once part of a continuous synclinorium.

The southwestern band, if so broken a series of outcrops can be so connected, is the most important of the three. This band, though the outcrops are for the most part narrow and inconspicuous, shows along its course several extraordinary fairly wide, lens-shaped masses of very rusty granular chert suddenly rising in castle-like form above the low muskeg. One of these monoliths, about 300 yards east from the narorws between Big island and the mainland of Kabenung lake, has a width of at least 90 yards, but dies out at less than 175 yards in green schists. This abrupt appearance and disappearance of knobs of the iron formation is very typical of this part of the area.

The belt of iron formation which is continuous for over one-half mile from the foot of Perry's bay of Kabenung lake to the south of White Water-Lily pond is also unimportant, having a maximum width of only thirty-five yards and dying out in quartz-porphyry schists to the eastward. The dip was observed to be about vertical or with very slight inclination to the south, and the average strike about east with variations from S. 55° E. to N. 80° E.

Lithologically, this portion of the Helen formation shows rusty banded cherts, banded jaspers and hard black chert. With them is associated black phyllite, and the formation is bordered by various sericitic schists. On one of the cross valleys, cutting the low ridge of hills, which represents geographically the Helen formation, and running at right angles to the main axis of White Water-Lily pond from its western end, some thin beds of bog iron ore were discovered. This deposit is small and local, and hence not of much economic value.

The belt which runs eastward along the low rise from the entrance of Elmo creek into lake Elmo is continuous for over one mile, dying out at either end in "tails" in mashed felsites and quartz-porphyrics. The band has for the most part a uniform strike, but shows major irregularities from north 80° east to south 75° east, besides numerous smaller contortions; and even breccias occur. It is of extremely uncertain width, being over a hundred yards across at one point and at a very short distance beyond rapidly narrowing to less than one-half of that width.

Lithologically, the iron-bearing rocks consist of interbanded chert and magnetite, and of rusty granular chert. Beds of chloritic green schist of uncertain origin are in some places interstratified, and very frequently mashed quartz-porphyry appears in connection with it. The latter is apparently older than the iron formation, and from its widespread occurrence, associated with the iron sediments, it is judged that erosion has removed by far the greatest portion of the iron formation, laying bare the underlying material. The lake Elmo band is thus of small commercial value.

Leach Lake Bands

Of the numerous synclinal bands and sub-bands once part of a wide synclinorium, occurring to the east of Leach lake, only three need be considered in a detailed way. These are bands 2, 3 and 4, which, uniting in a high hill about one-half mile to the northeast of Leach lake, diverge towards the southeast as V-shaped, prevailingly southeasterly pitching troughs. They are represented topographically by steep hills of irregular outline separated by deep valleys marking where erosion has cut through the iron formation and attacked the soft underlying schists.

The rocks of the Leach lake belt have a wide lithological variation, and show almost every phase of the Helen formation. They consist of rusty, sometimes highly magnetic, banded chert, often soft ore jasper, sideritic and pyritous chert, rusty quartzitic and granular chert, amphibolitic schist, and of small bodies of hydrous hematite and of silicious magnetite.

Band 2 is a canoe-shaped trough dipping to the southwest at a high angle, or standing vertically, and having apparently a major pitch towards the southeast. The iron formation is well exposed, and is seen to be bordered on either side by fine-grained chloritic schists. The band has a length of about 1,100 feet and dies out in lenses in schist at both ends, and is partly covered by sand-plain to the southeast. It has a maximum width, at about 100 yards northwest of the township line, of 225 feet. This width diminishes in either direction away from the maximum point and has an average of about 100 feet. The strike is as a rule uniform, running about northeast. The chert often shows an obscure lensoidal banding which may represent a friction breccia.

Band 3 is much the most prominent of the Leach lake bands, and is continuous for about a mile and a quarter. Towards the northwest the belt is narrow, having an average width of less than 75 feet, but at some 500 yards southeast of the point where it crosses the township line, it rapidly widens to 300 feet and in some places even

more, maintaining this width for almost one-half mile. Lithologically and structurally it is practically a repetition of band 2, but it was noticed that the rocks were rustier, more decomposed, less magnetic and more brecciated in band 3 than in band 2. Starting from its northwestern extension the strike varies from south 55° east to south 65° east, as far as a point some 500 yards beyond the crossing of the township line, where it changes more to the east and finally slightly to the north of east at its point of disappearance. The major pitch of the trough is probably towards the southeast and east, and doubtless there are several minor pitches in the opposite direction not shown by the field relations.

About one-half mile east of the township line a wide dike of greenstone cuts diagonally across the upturned beds, and as this dike is approached from either side, the iron-bearing rocks become highly ferruginous and locally so much so as to be called iron ores. At this point from various field relations it seems probable that the pitch of the syncline is from either side towards the dike, giving conditions fit for the formation of an ore body on either side. Several small ore bodies actually occur on the surface. One of these, an impure hydrated hematite, borders the dike on the west side. Two others on the east side of the dike occur close together and may in reality be one deposit. The most westerly is at least forty-five feet long and slightly narrower, while the other is apparently of much smaller dimensions and is as well much mixed with chert. The ore is a silicious magnetite not of very high grade, as shown by the following analyses:

	Fe.	S.	P.
No. 15	54.60	.08	.029

These lean ores are indicative of possible greater quantity and of better quality lower down the trough.

These deposits are known as Scott's prospect, and in the autumn of 1902 some preliminary exploration was done by the Algoma Commercial Company at this point, and several small houses erected. See sketch at page 336.

Band 4 is, in its geological structure and lithology, similar to bands 2 and 3. It merges with band 3 towards the northwest and dies out abruptly to the east. It has a total length of almost one mile, and an uncertain width varying from less than 75 feet to over 200 feet. The strike changes from south 65° east, towards the western end of the band to slightly north of east at the other end.

Sub-band A is an offshoot from band 3 at a point some 700 yards east of the place where that band crosses the township line.

Though the rocks of the Leach lake bands are rather poorly exposed, owing to the amount of drift on the hillsides, still for the most part the outcrops are sufficiently good to enable one to understand the field relations. Before the forest was so completely removed by fires this would not have been so easy a matter, for to the eastward, along the continuation of sub-band A, the forest growth is so thick and the few outcrops so small as to make the field study most difficult and unsatisfactory.

East of Godon Lake

About a quarter of a mile northeast of the northeast corner of Godon lake there are two low hills of iron formation. The crests of the hills are about 150 yards apart, and a shallow valley intervenes between the two. This low valley may indicate the presence of schist, but if it does not, and certainly no outcrops of schist are visible, then the total width of iron formation exceeds 150 yards. The band narrows to the southward, but is continued brokenly to the base of Diabase hill—a distance of about three-quarters of a mile. The iron formation comprises chiefly unbanded varieties of very pyritous and often rusty cherts, and very quartzose cherts. Very small deposits of bog iron ore occur near the north of the band. A specimen analyzed as follows:

	Fe.	S.	P.
No. 16	52.78	.14	.037

East of Pyrrhotite Lake

The occurrence of a deposit of magnetic pyrites or pyrrhotite lying to the east of Pyrrhotite lake and connected to it by a narrows, is scientifically exceedingly interesting as exhibiting a phase of the Helen formation in which the sulphide is the predominating mineral rather than the accessory. The dimensions of the deposit could not be accurately ascertained, owing to the amount of drift covering, but the Helen formation at this point has a maximum width of at least 50 feet and is continuous for quite 200 feet and probably more beneath the drift-covered hill to the southeast, though of course the sulphide deposit is much smaller. The deposit is simply a highly pyritous and pyrrhotitic chert, becoming rusty and much less metalliferous along its course to the southeast. Sometimes it consists entirely of pyrite and pyrrhotite with probably some magnetite, or again chert predominates. In places the sulphides are oxidized, producing a rusty "iron hat" of limonite.

A very rusty, much silicified, felsite schist borders the band to the northeast and a weathered sideritic schist to the southwest. This sideritic schist is also interstratified with the pyritous chert along its southeastern extension. The pyrrhotite does not carry nickel. The rusty limonite gives the following analysis:

	Fe.	S.	P.
No. 17	50.69	.72	.056

Some preliminary exploration work was carried out by the Algoma Commercial Company both east of Godon lake and at the pyrrhotite-pyrite deposits in 1900.

Eccles Lake Claims

The Eccles lake claims are thirty-two 40-acre claims situated east of the Magpie river. They stretch from north to south for a mile and a quarter at a distance of 2 miles to 3¼ miles above McKinnon's bridge. The claims were staked because of the occurrence of certain bands of the Helen formation within the green schists of the area covered. It has already been mentioned that geographically they belong with the eastern range, though they have a geological connection with the northern range as well.

The whole area is more or less rough and rocky, though no very pronounced hills exist. The valley of the Magpie is for the most part low and drift-covered, often with a sand-plain, while away from the river both to east and west low ridges of hills are divided by deep valleys. The country is completely bereft of timber, having been burnt some four or five years ago. Owing to this fact the exposures of rock are exceedingly good, and the solid rock not being much drift-covered, I had an excellent chance to study the region, and was enabled to elucidate many of the problems which had troubled me in other parts of the district.

The rocks of the area are the green schists so typical of the Michipicoten district. They consist of massive chloritic schists, seriticized and rusty quartz-porphyry schists, nacreous felsitic schists, which included sheets of granite and porphyry, and a peculiar lensoidly banded quartz porphyry schist, probably an autoclast, but often bearing a singular resemblance to a conglomerate. In the quartz porphyry schists, and sometimes in the massive chloritic schists, are the lenses of the Helen formation. All these rocks are invaded by numerous dikes and bosses of dolerite and diabase, and the region was evidently one of former volcanic activity. None of the lenses of iron formation are of any economic importance, and most of them are too small to be even discussed, consisting only of stringers a few inches wide and dying out within a few feet.

Band A, lying about a quarter of a mile south of Eccles creek, consists of a series of small broken lenses, running in an interrupted belt for some 800 yards. The lenses are mostly about three feet wide, and are of blackish and whitish crystalline chert, always intermixed with green schists. At half-way along the broken band (some 200 yards east of the boundary line between townships 28 and 29, range 26) the separated lenses collect to form a decided band of blackish and whitish chert with, in some

places, pyritous chert, and with a great deal of green schist. The schist and iron formation together are at least thirty yards wide, but the total width of all the lenses of iron formation within the schist does not exceed fifteen yards. Beyond this point the chert lenses soon narrow and die out in "tails" or appear as brecciated fragments of black and white chert or banded jasper in a matrix of soft green schist.

Band B is even narrower than the last, and is practically connected with it—the lenses arbitrarily specified as forming one band practically passing into and giving place to the lenses of the other. Like the last it consists of much impoverished magnetic black chert.

Band C lies nearer the northwest shore of Eccles lake. It consists of a number of broken lenses of banded jasper occurring in quartz-porphyry schists for some thirty yards across the strike, and is very much intermixed with schist. The lenses are traceable for some 190 yards in the direction of the strike, which is north 70° west, but in this distance the lenses often die out and only brecciated fragments are visible in the green schists. Again they reappear as tails to continue some sixty or seventy feet, then to die out again or give place to other lenses a few feet to the south or north. The widest lens was observed to have a maximum width of eight feet, and the total width of all the lenses at this point was scarcely twice that width.

Band D, which occurs some 150 yards south of the last, is of much the same general character. It has a strike of north 80° west, and dips vertically. Like the last, the iron-bearing rock is made up almost entirely of banded jasper, and in places the magnetite constituent of this rock predominates, and small seams of rather impoverished crystalline black magnetite and red hematite are found. The band was traced with several gaps, for over a quarter of a mile. It is widest some fifty yards from the lake shore, where it has a width of about eighteen yards and consists of blue-black impoverished magnetic jasper interstratified with red crystalline chert. Beyond this point the bands die out, but re-appear prominently at 110 yards and again at 300 yards.

It is evident that the scattered and disconnected lenses of iron formation, observed on the Eccles lake claims, are the remnants of former much larger bands which have been almost entirely removed by erosion, leaving only narrow shallow troughs to mark what were probably minor synclines in a larger synclinorium before sub-aereal erosion had proceeded so far as it has at present.

SPECIAL AREAS OF THE WESTERN RANGE

Near Mouth of Julia River

Outcropping prominently on the Lake Superior shore about three and a half miles southeast of the Pucaswa river, on the prominent rocky point beyond the mouth of the Julia river are ten narrow parallel bands of Helen formation. They differ so materially from each other in lithological characteristics that it will be well to describe each one separately, beginning at the most westerly, and numbering towards the east.

1. Band number 1, of rusty even-banded chert has a thickness of four feet. It is underlain by soft green schist and overlain by diabase, which appears sheet-like but which may be a dike cutting across the dip but parallel with the strike. Northwesterly from the dike along the shore, squeezed porphyrites are cut by numerous diabase dikes.

2. Some seventy feet southeast of band number 1 occurs the second band. It has a maximum thickness of 5 feet 7 inches, and strikes north 40° east and dips at 34° in a northwesterly direction. It is traceable for about 125 feet inland from the shore, and is then lost beneath drift covering. The overlying green schist looks agglomeratic, but is probably an old lava. The iron formation consists chiefly of jaspyllite, with bands of bright crimson jasper and sparkling specular hematite. Sometimes it is

slaty and pyritous. A narrow sheet of diabase four inches thick is interstratified. The jaspyllites are often highly ferruginous. A sample taken for analysis gave the following result:

	Fe.	S.	P.
No. 18..	46.41	.06	.092

3. Band 3 lies some twenty feet southeast of number 2. It dips at an angle of 24°, has a thickness of three feet nine inches, and consists chiefly of dark grayish chert. The beds show many faults, of small throw, the planes of which are cemented by calcite. Above the bed lies a schist of agglomeratic appearance.

4. Sixty-five feet southeast of the third band is the fourth band—a lens of chert two feet thick. It is underlain by evenly banded schist and overlain by a schist which looks agglomeratic. The band is traversed by a dike of diabase six feet wide.

5. Band 5, twelve feet southeast of number 4, is ten feet thick and consists of mixed impure jaspyllites and slates. It is underlain by a schist which is apparently an altered amygdaloid.

6. About 125 feet from the last band is the sixth band, only three feet thick and much mixed with phyllite.

7. At 25 feet southeast of number 6 lenses of jasper often very ferruginous, occur with ferruginous phyllites, the band in all being four feet thick and underlain by epidotic and nacreous felsitic schists.

8. Twenty-five feet beyond the last is the eighth band, which is a narrow lens of pyritous banded chert eighteen inches thick.

9. One hundred and twenty-five feet southeast of number 8 is the ninth band, three feet thick and consisting of chert, phyllite, etc.

10. The last band lies twenty-five paces beyond the ninth. The band consists from the bottom up of one foot of banded chert, two feet of soft chloritic schist, then four feet of banded, often highly ferruginous cherts and phyllites. The whole band is underlain by chloritic schists with narrow sheets of whitish felsite and overlain by chloritic schists.

All the bands of iron formation dip at angles less than 45° to the northwestward. The structure is apparently monoclinal, and there is no evidence of reduplication by faulting or folding It will be seen that in a thickness of about 293 feet of rock allowing an average dip of 35° for the horizontal width of 494 feet of schist, about 42 feet consist of sedimentary rocks of the iron formation, and the rest are apparently wholly schists of igneous origin, or for the most part of igneous origin. These bands lying near the mouth of the Julia do not seem to be of much economic value, unless the content in iron increases downward as is possible, but they are interesting as representing the type of all the western range proper—that is, of exhibiting a number of parallel beds of iron formation interstratified with schists and having what seems to be monoclinal structure. See sketch, page 336.

Laird's Claim

About three and a half miles north 20° east of the bands near the mouth of the Julia river is Laird's claim, on which occur several bands of iron formation exposed, and probably others beneath the drift, which though not outcropping are indicated by a strong magnetic attraction in crossing the strike of the beds. In going north the most southern band is the first prominent outcrop of solid rock which appears above the sand-plain stretching north from Julia river. It rises as a low cliff about nine feet high. The band of iron formation is about thirteen feet thick at the thickest point and consists of magnetic phyllites and highly magnetic banded chert, composed of impure magnetite, with bands of grayish black chert. For the most part it is almost sufficiently ferruginous to be called a lean iron ore. An analyses of a representative specimen gave the following result:

	Fe.	S.	P.
No. 19..	36.24	Traces.	.072

Overlying the iron formation is a schistose porphyrite, while beneath it is a soft chloritic schist. The band is continuous for about a quarter of a mile, and lenses out in schist to east and west. The formation has a gentle northern dip of about 16° or 18°.

North from this band lenses of magnetic chert appear in the schist for over a quarter of a mile. None of these are, however, of any prominence save the most northerly. This band is about four feet thick and dips to the northward at about 20°. It is not nearly so ferruginous as the southern band described, and consists of somewhat crumpled banded chert, under and overlain by grayish chloritic schist.

Bands North of Julia River

Stretching eastward from Laird's claim is an iron-bearing horizon over a quarter of a mile in width. This iron-bearing horizon consists by no means entirely of rocks of the iron formation, but within it occur frequent lenses and definite bands of generally very magnetic chert which are visible perhaps for a few yards only or perhaps for nearly one hundred yards, and in general the whole is very much drift-covered. Very detailed investigations will be necessary in this locality before the value of these scattered lenses of magnetic chert or, often more correctly, impure cherty magnetite, can be ascertained; but from the brief survey that we were able to give it, it would seem to be a horizon well worth while prospecting. I would suggest the carrying out of very careful magnetic work, and where that work warranted it, stripping, if this were as all feasible, otherwise the sinking of test-pits or small prospecting shafts.

The most prominent of these bands occurs a few hundred yards north of the Julia river, and about four and a half miles north of the Lake Superior shore, north from a point opposite the first considerable island southeast of the mouth of the Pucaswa river. The lense consists of bluish-black cherty magnetite, with which is interbanded some whitish chert and banded grayish chert. In places it is overlain by a magnetic phyllite, and again by a highly schistose porphyrite. The band dips in a northeasterly direction at an angle of about 33°, and strikes north 65° west. The thickness of the bed is rather uncertain, but it is probably twenty-four feet and may be more. For the most part the bed is highly ferruginous. The following analysis is that of a specimen of impure magnetite chert but there are other specimens containing a much higher content in iron:

	Fe.	S.	P.
No. 20..	38.37	.06	1.8

The bed outcrops for about fifty yards to the westward from the highest point of the cliff in which it appears, and is also visible at intervals for 150 yards in the opposite direction.

David Katossin's Claims

David Katossin's claims lie north of David's lakes, and are staked on bands of iron formation which occur in chloritic schists for nearly a quarter of a mile across the strike, and extend brokenly for over a mile in the opposite direction. The widest band which is also the most southerly, has at its widest point a surface width of 115 feet. It has a general strike of N. 80° W., and dips at 45° northward. On the north side of this band the iron formation consists of interbanded bluish impure magnetite and grayish chert. In the middle it is rusty and contains considerably sugary chert, while on the south side it is a somewhat magnetic chert. An analysis made of a rich specimen from this southern band gave the following result:

	Fe.	S.	P.
No. 21..	43.58	.10	.076

All the lenses and bands of iron formation on David Katossin's claims seem to be of very uncertain width and length, and in fact this is a characteristic of the whole western range. The bands may have a fair width for a few yards and then perhaps suddenly narrow and die out, giving place to another short lens or band,

north or south of the last, which in its turn will extend some distance, and finally give place to another. The structure of the bands is apparently a series of monoclinal folds. The strike varies from N. 80° W. towards the west of the claims to N. 50° E. towards the east where cut off by granite near the Pucaswa river. As a rule the rocks consist of evenly banded magnetic cherts, but sometimes the cherts are impoverished, contain very little iron, and are crumpled or even brecciated. Like all parts of the western range, the iron formation on the David Katossin claims is much drift covered and in addition it is traversed by wide dikes and bosses of diabase and gabbro.

North of Maple Lake

Stretching from the edge of the granite on the west and extending along the northern shore of Maple lake eastward beyond Lost lake to Cameron lake, is an iron-bearing horizon in which only occasional lenses of banded magnetic chert or very cherty magnetite outcrop above the generally drift-covered surface. North from a point near the west end of Maple lake a band of magnetic and quartzitic chert appears which is at least thirty-five feet wide. It stands vertically and strikes east. This lens can be traced brokenly as far as the creek which flows from Maple lake northward to a small pond. Along this creek a good section was exposed, and may here be given in detail, measuring from the shore of Maple lake.

570 ft.—574 ft.	Lens of banded black and grayish chert, interbanded with soft grayish phyllite and narrow sheets of granite.
574 " —665 "	Soft green schist.
665 " —670 "	Sheet of granite.
670 " —883 "	Probably all schist.
883 " —890 "	Lens of banded magnetic chert.
890 " —927 "	Schist.
927 " —934 "	Lenses of rusty sugary chert.
934 " —992 "	Probably all green schist.
992 " and northward, granite.	

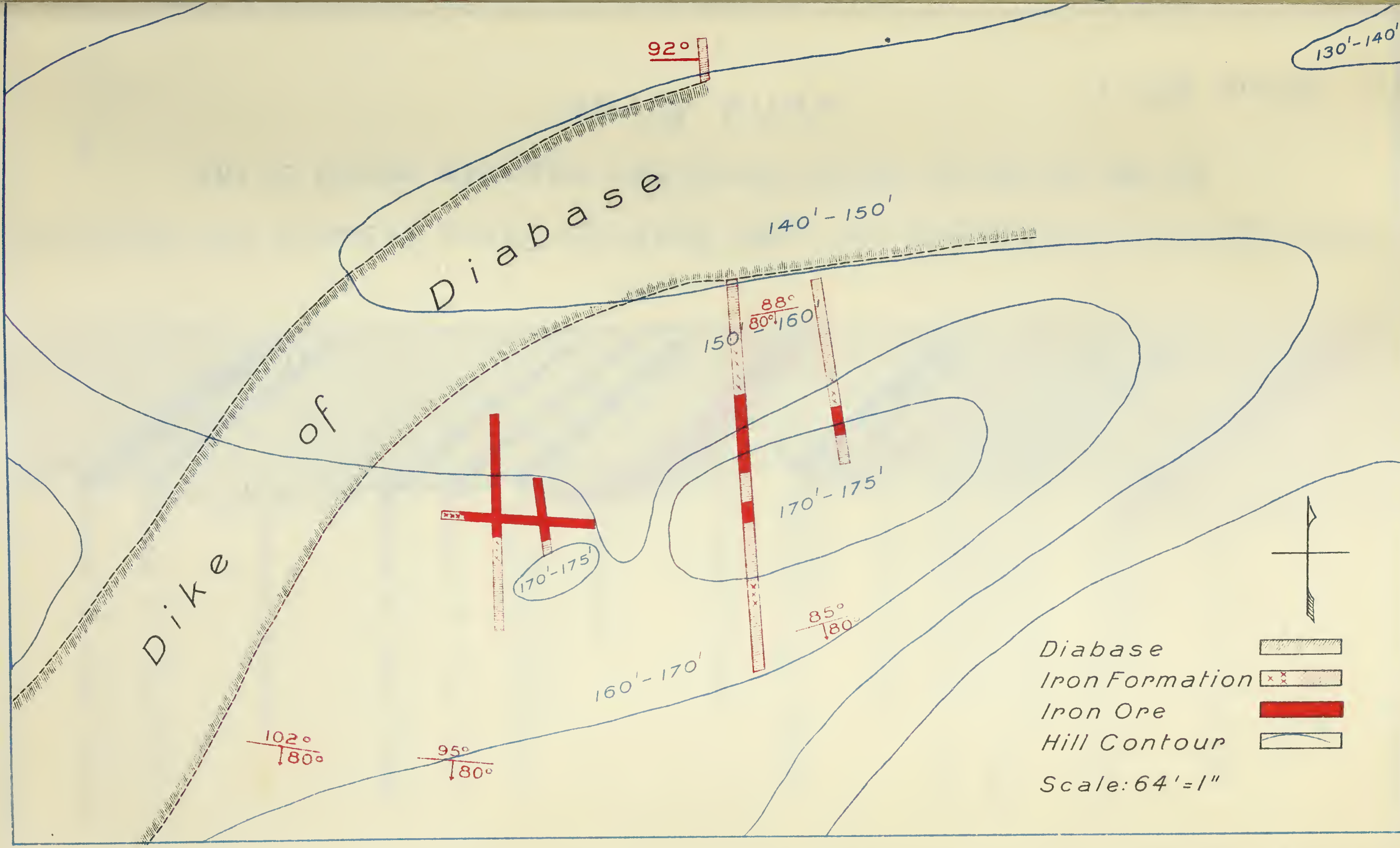
A representative specimen of iron formation from north of Maple lake analyzed as follows:

	Fe.	S.	P.
No. 22	29.17	.51	.076

North of Lost and Cameron Lakes

East from Maple lake only isolated outcrops of magnetic chert appear, but it is evident from these few scattered exposures that the iron-bearing horizon is continuous, and that iron-bearing rocks are interstratified with schists all the way. On the hills rather more than a quarter of a mile north of Lost lake three more or less definite bands occur within a width of about 110 yards, and are continuous to the top of a high hill just west of Floating Heart creek. The widest band is about 25 yards across, and the others not much narrower. As the dip is vertical, the width on the horizontal corresponds with the thickness. The iron formation consists in the main of very evenly banded and rusty chert not very ferruginous. The strike is about N. 70° E.

West of Cameron lake the iron-bearing horizon is very wide. Lenses appear on the portage from Floating Heart creek into the north end of the lake, and again on the portage from the south end of the lake into the creek again, or more than half a mile wide. Most of the iron formation, however, is associated in a belt which starts at the base of the prominent hill about half way down the west shore of the lake, and is continuous west to the creek—or a little over half a mile in length. This belt is about 150 yards wide and about half of the width consists of iron formation, comprising banded magnetic cherts, rusty saccharoidal cherts, whitish opalescent cherts, and non-magnetic banded cherts. With these iron-bearing rocks are associated crenulated and contorted chloritic schists, which often resemble phyllites and soft whitish felsitic schists. The dip of the beds is about vertical, and the strike varies from N. 62° W. to about east and west.



Sketch Showing Stripping on Iron Ore Deposit at Scott's Prospect.

Cross Section of Portion of the Lake Superior Shore showing the structure of the bands of Helen Formation near the mouth of the Julia River.

Scale: 80' = 1"

Near Fall Creek

A great many narrow lenses of iron formation occur in the green schists near the shore of Lake Superior west of Fall creek. Only a few of these are sufficiently long and wide to deserve mention. One occurs about two and three-quarters miles north 20° west of the mouth of Fall creek. It is about fifteen yards wide and is traceable for upwards of a quarter of a mile along the edge of a high cliff rising above Fall creek. It consists of very evenly banded grayish and black chert. Another lense lies in the schists some two miles northwest of the mouth of Fall creek. It consists of weathered jaspyllite, is where widest about two feet wide, and is traceable for a little over one hundred yards. Two narrow bands of iron formation in green schists may be seen on the shore of a small bay just west of Fall creek. The western band which is about three feet thick, consists of impure reddish chert mixed with schist, and the eastern band which is three to four feet thick, is composed of a highly ferruginous jaspyllite. The bands are twenty-five feet apart on the horizontal, and between them lie rusty chloritic and sericitic schists. Both bands dip to the eastward at about 45° and strike N. 5° E. Beneath the western band lie rusty sericitic schists, and above the eastern band rusty chloritic schists.

Edey Claim

From the area just described, belonging to the western Michipicoten range proper, the iron formation on the Edey claim differs very materially. The band has a length of about 275 yards and a maximum width of about 50 yards. A narrow band appears parallel with the main to the south for a few yards. The rocks are but slightly magnetic, and consist for the most part of highly ferruginous but non-magnetic banded cherts and rusty sugary cherts. The structure is very complicated. The band represents the base of an intensely corrugated syncline, very much faulted, the faulting taking place chiefly parallel with the axis of the minor longitudinal synclinal folds which make up the main synclinal. The trend of the band is about N. 70° E., and the dip of the beds usually to the northward at 50° to 70° The pitch in the short length of the bands changes in its direction several times, and is often at as high an angle as 45°. Soft chloritic schists underlie the Helen rocks, and owing to the enormous longitudinal folding and transverse folding which the rocks have suffered, the schists are brought to the surface and appear to interstratify with the Helen rocks and even replace them entirely along the strike at the summits of the transverse anticlinal folds. The band is not of much economic importance, since the amount of iron formation present is probably too small to have ever produced a large ore body.

Lorne Prospect

Some ten miles north 20° east of the mouth of the Pucaswa river, in a small area of hornblendic and micaceous schists, inter-sheeted with and also cut by gneissoid granites, occurs the Lorne prospect. The deposit, so far as the writer knows, is unique in the Michipicoten area, and consists of a highly mineralized zone in the schists. The metallic minerals present comprise chiefly magnetite, pyrite, chalcopyrite and pyrrhotite. In a somewhat rough way the deposit may be said to have a length of about 145 yards and a breadth of a least 48 yards. These dimensions do not mark the limits of actual mineralization, since the hornblende schists to the eastward and westward give a strong magnetic attraction and even contain lenses of magnetite.

The surface of the deposit consists in the main of a rusty bog-iron ore of variable thickness, but never exceeding a few inches. Within the limits of the deposit occur narrow streaks of relatively rich material within areas of schist of slight mineralization or none at all. The schists vary in strike from N. 55° E. to N. 75° E., and dip at a high angle northward. Narrow sheets and dikes of granite, which is often porphyritic or pegmatitic, occur in and traverse the deposit, and a dike of diabase which runs about N. 20° W. cuts across the beds near the western end of the hill which represents

the deposit topographically. The exact limitations of the area of hornblende schist in which the deposit is found, were not ascertained; but it certainly is not wide, and as porphyritic granite outcrops on the shore of McDougall lake to the northeast of the deposit and at a short distance southward along the trail leading southwest to Camp lake. It is probably but a narrow band of Huronian schists—an inlier enclosed by the later granite, and is but a large example of many of the smaller inclusions contained in the post-Huronian acid eruptives. The connection supposed to exist between this small area of schists, and the arm of Huronian rocks stretching westward from Iron lake, has already been mentioned.

Magnetite is by far the commonest metallic mineral, but the sulphides are sometimes quite common. The limonite or rusty "iron hat" is probably often merely a rusty schist. As an ore of iron, surface specimens are too low in iron and often too high in sulphur. Analyses were made of representative specimens taken from various parts of the deposit. Number 22 shows a schist containing comparatively little magnetite from near east end of hill. Number 23, impure magnetite from west end of hill. Number 24, impure magnetite from south side of hill, near the main test pit sunk by prospectors recently working on the deposit. Number 25, the rusty limonite coating from the south side of the hill.

	Fe.	S.	P.
No. 22	25.72	.07	—
No. 23	40.92	3.20	.014
No. 24	40.17	9.39	.024
No. 25	53.75	.34	.03

In general the last three analyses may be considered slightly higher than the average for the whole hill, since the south side is apparently much richer than the north side.

The origin of this peculiar deposit is uncertain. It was probably originally a bed of ferruginous chert in chloritic schists, or interstratified beds of cherty iron carbonates varying in their content in lime, magnesia and ferrous oxide. By the metamorphism of these beds, due to the heat produced by the immense intrusions of granite, the chloritic schists or cherty carbonates high in lime or magnesia, were converted into hornblendic schists, while the ferruginous cherts or cherty carbonates high in ferric oxide were changed into schists rich in magnetite. The other metallic minerals may also have been products of metamorphism. However, this may not have been the origin, the magnetic schists may have originally been ferruginous slates, or some of the metallic minerals may have been of secondary introduction, being brought in at the time of the granite intrusion. Beneath the microscope the hornblende schists have a somewhat igneous appearance due to the presence of the mineral plagioclase, but this mineral is entirely of secondary origin, and hornblende schists undoubtedly produced by metamorphism of sedimentary rocks are certainly found in Michipicoten as seen north of Narrow lake and lake Charlotte.

A considerable quantity of low grade impure magnetite certainly exists at the Lorne prospect, and possibly further prospecting work, of which very little has yet been done, may prove the presence of richer material. If the schists are a much compressed series enclosed in a basin of eruptive granite, it would seem natural to expect an enriched deposit towards the base of this basin resting on the enclosing granite. The presence of this enriched deposit may be discovered when stripping or test-pitting has been carried out in the low ground around the base of the hill near the narrow sheets of granite, or may only be located by small prospecting shafts or diagonal drill holes.

Resume

It will be seen from a perusal of this short disquisition on the iron formation that by far the greatest part of the once extensive Helen sediments have disappeared. Doubtless enormous quantities of disintegrated ores were carried away by the strong

glacial corrasion which has laid bare the rocks in every part of the Michipicoten district, and these ores have by no means been appreciably replaced by concentration since glacial times. On the other hand glacial denudation has been most unequal in different parts of the district, doubtless more or less influenced by pre-glacial topography; and whereas in some parts of the district the entire formation, both disintegrated and non-disintegrated, has been removed, in other parts a considerable portion of the latter still remains, and it is to these parts attention ought to be drawn.

In the northern range the beds are everywhere folded into intensely compressed folds, and concentration of the ores has been found to take place at or towards the bottom of the troughs. Only in so far as the lower part of the trough was in the zone of corrasion would the concentrated ore be swept away. Therefore in the still existing deep troughs, since by far the greatest part of ore concentration took place prior to the period of glacial denudation, when the Helen formation was still extensive, it is reasonable to expect that ore-bodies of considerable magnitude may be found. Deep troughs of this nature may be said to exist at Iron lake, at the Frances mine, at Brotherton hill, and at the Leach lake bands, especially near Scott's prospect.

In the western range structural conditions are very different from the northern range. The beds are broadly folded, but not nearly so intensely corrugated as on the northern range. For this reason we get them appearing in monoclines, or what appear to be monoclines, though the angle of dip of the beds varies from 12° to vertical. Gentle cross folds may traverse the monoclines, producing shallow troughs in which ore enrichment might be expected, or dikes or bosses of eruptive rocks, undoubtedly present, may have in some cases given the necessary basin. It is very possible that faulting, particularly faulting parallel with the dip and strike, may be very common in both the northern and western ranges, and this may in many cases give departures from the general rule of ore deposition and ore deposits.

In general, the iron formation at the surface in the western range is much more highly ferruginous than on the northern range. This is supposed to be due not so much to any original difference between the beds in the two ranges, but to the fact that, owing to the more broken up, brecciated, jointed and faulted condition of the iron formation in the northern range, concentration of the iron ores at the bottoms of troughs has gone on to a much greater degree there than on the western range. On the whole, this may be considered an unfavorable sign for the western range.

It may be suggested that the beds of iron formation on the western range are not sufficiently wide to have ever produced a large ore body. At first sight this would seem to be the case all over the range, and probably for many localities this objection is a good one. However, it must be remembered that in the case of the western range we speak usually of the thickness of the beds and not of the width of the bands, as in the case of the northern range. In the northern range, owing to the intense plication, the width of the bands represents the thickness of the individual beds, many times multiplied. For example, in the case of the Iron lake area we have no means of telling how thick the original bed of iron formation was, but we do know the width of the band—often 600 feet or more. Now that width probably represents the thickness of the original bed at least twenty-five times repeated, so close has been the folding. It may be supposed that the lateral extent of the original beds of iron formation was not less on the western range than on the northern range, proportionate of course in both cases to the thickness. For this reason we might naturally expect as large an ore-body to be derived from a fairly thick bed of wide extent, along the strike and down the dip, as from a wide band of considerable depth, within the limitations that the amount of iron formation was approximately the same in both cases, that the two iron formations were equally rich in iron, and that the means by which concentration took place were equally good for both. Among localities of fairly favorable appearance on the western range may be mentioned Laird's claims, Julia river bands, David Katossin claims and Lost lake.

In general, the exposures of the Helen rocks are not nearly so good on the western range as on the northern, and the structure in many cases could not be so well ascertained in the former as in the latter. The great folding on the Edey claim, as compared with the comparatively gentle folding on the Julia river bands and elsewhere, may be explained by the fact that the Edey claim is close to the centre of greatest plication (close to the edge of the granite), whereas the more gentle folded areas are more remotely removed. For a similar reason, the beds of iron formation from Maple lake to Lost lake stand at higher angles than those of other localities.

THE UPPER HURONIAN

Doré Formation

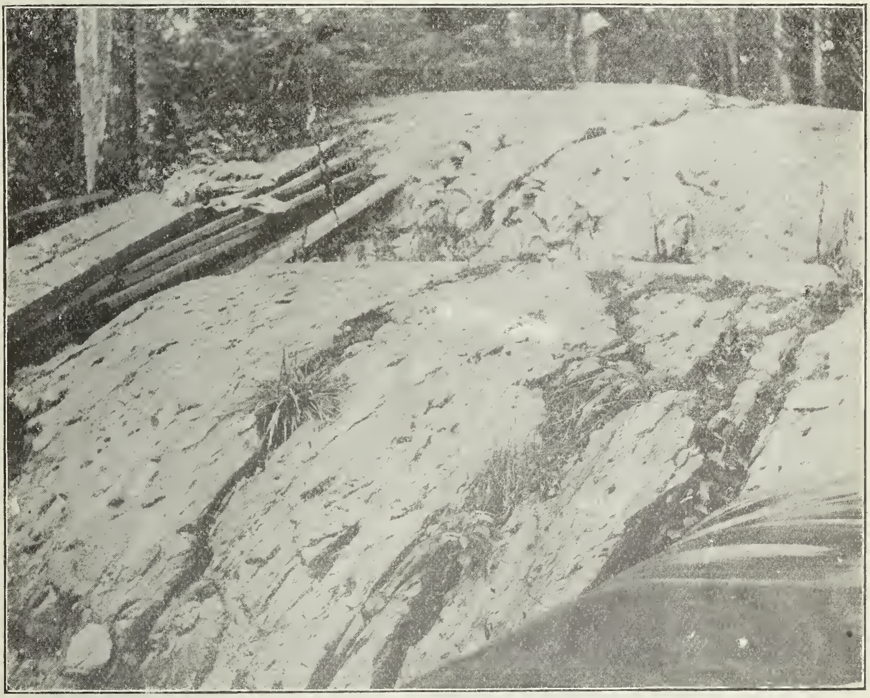
In a general way the Doré Formation is spoken of as the Doré conglomerate, but there are Doré agglomerates, Doré tuffs, and Doré slates, contemporaneous with the conglomerate, though the latter composed by far the greatest part of the formation.

PETROGRAPHY OF THE CONGLOMERATE

The Doré conglomerate is the most extensive true waterlaid sediment in the region. It is an exceedingly mashed rock consisting of a rather fine-grained matrix in which are embedded fragments of every size from those truly microscopical up to others two feet in diameter. All the pebbles are elongated, some nearly oval-shaped, others drawn into long narrow ribbons, or again completely granulated, their character lost and even under the microscope scarcely distinguishable from the matrix proper. Megascopically, the matrix often resembles a soft grayish chloritic schist, very much decomposed, occasionally rusty, and where pebbles are absent in some places indistinguishable from a schist formed from an igneous rock. Beneath the microscope the prevailing clastic material of the matrix consists of quartz and chlorite, the former in small rounded grains, the latter in irregular frayed flakes. With these primary minerals occur a great deal of secondary infiltrated carbonate, often more or less oxidized with the formation of hydrous iron oxide; much chalcedonic silica, much sericite, fairly coarsely crystalline quartz; foils of muscovite and idiomorphic crystals of pyrite. This latter secondary material occurs as re-cementing substance chiefly with the crushed and granulated matter formed from the contusion of the smaller pebbles. These crushed pebbles, generally derived from rocks of igneous origin, mix with the altered material of the original matrix strained plates of various decomposed feldspars, and more or less worn grains of much altered ferro-magnesian minerals. Thus the matrix is given in many places the appearance of a typical igneous rock, and with all the pebbles comminuted, might easily be mistaken for a rock of that origin; but as a rule the real nature of the rock is apparent in the field and the extreme phase of dynamic metamorphism is rarely seen even beneath the microscope. Even where the matrix includes no additions derived from the pulverization of the pebbles, it contains comparatively little original material and consists chiefly or in great part of secondary minerals. Thus its former character is entirely changed, and little clue as to its primary condition is gained by its microscopic study. Probably it was originally a rather sandy, argillaceous material.

In some parts of the areas, as southwest of Black Trout lake, near the Magpie river, the matrix of the conglomerate very strongly resembles a rusty sericite schist —and since it contains many rounded fragments of bluish quartz, it has the general appearance of being an altered quartz porphyry. In addition to quartz grains the matrix contains zircon, magnetite, and altered feldspars which are probably primary fragments, and biotite and chlorite which may or may not be secondary.

Like the matrix, the pebbles are much decomposed. The following rocks are represented: chert, quartz, quartz-porphyry, massive basic igneous rocks, fine-grained schistose rocks of various colors, porphyrites, black slate, and finally in places granite. It was seen that the proportion of these rocks to each other varied greatly from point to point. In some places, particularly adjoining the iron formation, cherty rocks predominate, or are at least of great consequence, while farther away they are entirely wanting. Pebbles of a light colored soft rock, with blebs of glassy quartz occurring in a sericitic ground-mass—probably an altered quartz-porphyry—and others of a grayish much altered and generally porphyritic granite, are perhaps in general the most common. The pebbles of the former sort are probably derived from the mashed quartz-porphyries which form such an important part of the volcanic rocks of the Lower Huronian, but the derivation of pebbles of the latter description is not so easily found, and to my knowledge there is at present no similar granitic rock of age earlier than the conglomerate existing in Michipicoten from which these very characteristic



Doré conglomerate, near Michipicoten Harbor.

pebbles could have been derived. It is very likely that pebbles of the softer schists and less silicious rocks were originally much more common than they are at present, and often are still seen, but the intense shearing which the formation has undergone has as a rule so broken them up that they are no longer visible or are indistinguishable from the matrix. In some places the pebbles in the conglomerate are so closely packed as practically to exclude the matrix, again the matrix may very much predominate and pebbles be visible only at wide intervals. The granitic pebbles do not generally resemble the post-Huronian granites. They are much more porphyritic than is usual with the granites of that age.

The quartz pebbles result evidently from the disintegration of the small stringers and veinlets of this mineral which are of common occurrence in the Michipicoten schists, but not from the larger veins which are probably of later age than the conglomerate. The pebbles derived from the Helen iron formation included in the Doré

conglomerate are mostly of the coarsely granular chert or "sandstone jasper" type, though a few show distinct banding and are obtained from impoverished banded jaspers. The occurrence of these pebbles of banded jaspers seems to me a further proof that not all of these rocks composed of interbanded layers of iron oxide and of chert, have resulted from the metasomatic alteration of cherty carbonates, since these alterations could not have taken place beneath water and the disintegration of the Helen formation started as soon as it was elevated above water.

The pebbles of the massive basic igneous rocks are so much changed that their original character can barely be guessed, but it is presumed that they are derived from the coarse-grained greenstones, often schistose, which are so common near the base of the Lower Huronian series. Pebbles of the more easily decomposed schists are scarcely visible in the conglomerate, save as long drawn out ribbon-like lenses and these, completely chloritized, so much resemble the matrix as to be indistinguishable from it, save occasionally by the difference in color in the hand specimen. A few pebbles of black slate or phyllite were observed in several places, and the fact of their occurrence in the conglomerate is of interest in showing that at least some of the rocks of this character belong not to the Upper Huronian but to the Lower.

PETROGRAPHY OF THE AGGLOMERATE

At some few places associated with the conglomerate and grading imperceptibly into it, is a soft greenish schist containing numerous rounded, lensoid or ribboned pebbles, or more correctly what at first sight appear to be pebbles, but which on closer examination are seen to be all lithologically similar, and are apparently bombs, lapilli, or other volcanic ejectamenta. The matrix of this agglomerate very closely resembles megascopically that of the Doré conglomerate, but microscopically the igneous origin of the former is shown. In the field the pseudo-pebbles weather lighter than the matrix, giving it a peculiar blotched appearance which is very distinctive. Typical exposures of this pyroclastic rock are visible on the portage from Pitch-pine lake to the Dog river and on the portage from the Frances mine to the Dog river.

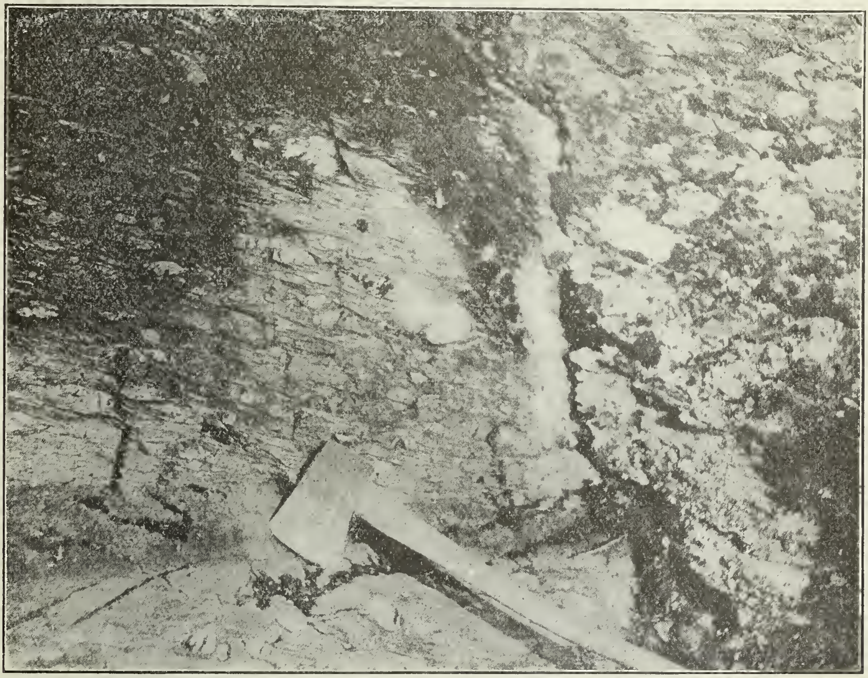
In both these instances the agglomerate is directly interstratified with the conglomerate. Where, however, agglomerates occur which are not directly associated with conglomerates, then it is not so easy to consider them of Doré age. Agglomeratic rocks which are probably Lower Huronian in age are common, and these can hardly be distinguished from those of Upper Huronian age. Agglomerates appear on the shores of the sixth lake north of Dog River harbor, on the route to lake Michi-Biju, which are of uncertain age. The ground-mass is a light greenish, chloritic, felsitic schist, in which are embedded the felsite and quartz fragments, elongated parallel to the schistosity. Similar rocks are found on the Lake Superior shore, about two miles west of the Dog river; on Catfish creek, some three miles north of Catfish lake; at the northeast corner of Catfish lake, and at many other points. Without direct association with Doré conglomerate there is no reason why these rocks can be classed with them, and for the present they are considered Lower Huronian.

A somewhat rare phase of the Doré agglomerate is one in which the larger fragments disappear. The agglomerate may then be considered a tuff. From the occurrence of the Doré agglomerate it is evident that volcanic activity continued during Upper Huronian times, laying down volcanic beds in connection with the waterlaid sediments of the conglomerate.

At a great many places in the Doré formation extensive and unequal denudation has brought to the surface the underlying green schists, some of which, as already described, are altered tuffs. These may resemble the agglomerates and fine-grained tuffs contemporaneous with the Doré conglomerates, and may not easily be separable from them.

PETROGRAPHY OF THE SLATE

A somewhat uncommon phase of the Doré conglomerate is one in which pebbles are entirely lacking. This is practically a slate or phyllite, closely resembling the argillaceous rocks belonging to the Lower Huronian, with which it might be erroneously classed from lithological considerations, were it not for its intimate connection with the Doré conglomerate. The long point which divides Minnesota bay from the southwestern bay of Iron lake is composed at least in part of this Upper Huronian



Doré Conglomerate, Iron lake.

phyllite, and similar rocks occur with the Doré conglomerate, just east of the mouth of the Dog river.

The Doré conglomerate must not be confused with the various pseudo-conglomerates which occur so widely and are almost indistinguishable from the water-formed rock. Several of these have been already described. They are usually autoclastic rocks, and a typical example is that resulting from the brecciation and subsequent rounding by mashing of small lenses of jasper and quartz occurring in soft quartz-porphyry schists. This phenomenon is well observed on the Eccles lake claims, where in places the sericitic schists form the matrix of false-pebbles of quartz jasper.

DISTRIBUTION OF THE FORMATION

The distribution of the Doré formation is extensive throughout northern Michipicoten. Starting near the entrance of Farwell creek into the eastern branch of the Pucaswa river on the west, it extends as a continuous belt in a direction north 70° east to the south shore of Iron lake. South of the western end of Minnesota bay the formation outcrops for slightly over a mile across the strike, and as a sand-plain borders it to the southward, this width may be somewhat increased. From Iron lake the band gradually narrows, and where it crosses the Dog river is probably under half a mile in width. An isolated outcrop of the conglomerate filled with chert pebbles,

occurs in the eastward continuation of the trough between the two bands of iron formation on the Katossin claim. This outcrop is probably one-quarter of a mile north of the main belt of the Doré formation, and indicates its former greater extension. The phyllites occurring at the Rapid of the Drowned on the Dog river and cut by a small dike of acid quartz porphyry at the southern end of the portage from Pitchpine lake to the Dog river, are probably of Doré age.

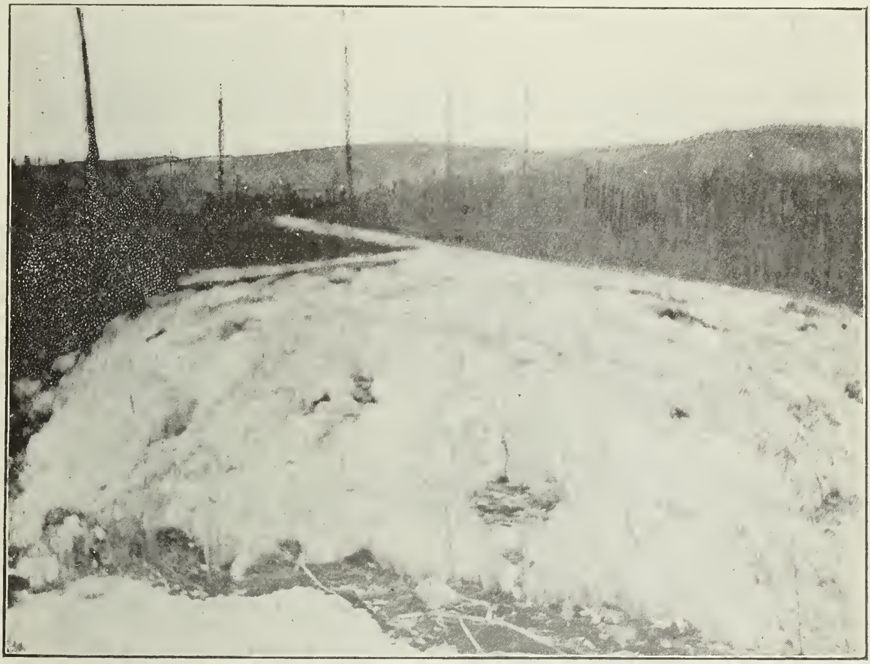
From the Dog river the formation runs east towards Paint lake. At the western end of the lake no outcrops of the formation were seen, but it reappears north of Paint lake and continues eastward to Kabenung lake, just south of and opposite Iserhoff island, where it is cut off by granite intrusives. North of Paint lake the Doré formation is nowhere continuous and unbroken, exposures of the conglomerate alternating with outcrops of sericite schists, and other earlier rocks. Evidently erosion has cut through the later rocks and exposed the underlying. An isolated appearance of a conglomeratic looking rock was seen about half a mile west of Crayfish lake, just beyond the boundary of the granite. It is doubtful whether it is to be connected with the Doré formation.

North of the Kabenung granite mass, the Doré formation reappears along the north shore of lake Charlotte. West of lake Charlotte outcrops of the conglomerate are wanting as far as the northern neck between east and west Kabenung lake, where the formation is observed to be running about southeast, and it continues in this direction as far as White Water-Lily pond. Here it turns abruptly and passes off to the north of Leach lake in a more or less easterly direction, than northeasterly. North of Water-Lily pond the width of the formation is some 700 yards, but appearing frequently with the conglomerate are outcrops of the mashed quartz-porphyry, again showing that erosion has eaten in many places through the Upper Huronian and brought the older rocks to the surface. North of Leach lake the Doré formation bends around the intruding granite boss, and passing to the north of Lonely lake crosses lake Desolation.

Eastward from lake Desolation no rocks certainly belonging with the Doré conglomerate are found, but there are rocks which may be part of that formation and which are tentatively classed with it. These rocks which consist of a fine-grained chloritic and micaceous matrix, with many "pebbles" or what appear to be pebbles of granite, felsite, and rarely quartz embedded within it, may be conglomerates; but from the fact that no definitely clastic material is discoverable beneath the microscope they cannot be definitely said to be water-formed. Moreover, the pebbles consist in the main of the same elementary minerals as the ground-mass, which gives it the general character of a volcanic breccia or agglomerate. However, the fragments are frequently rounded and resemble pebbles or cobbles worn in or by water. Again, on the other hand, they are sometimes drawn into long lenses, but certainly true conglomerates contain pebbles drawn into similar lenses. Another point which seems to suggest their not being true conglomerates is the absence of pebbles of all rocks, not of the same character as the matrix, save quartz. "Fragments" of quartz are comparatively rare, and those found may not in reality be true fragments, but may be material introduced by solutions after the laying down of the rocks, since they are generally long and lensoid, like tiny veinlets. In the field, however, these rocks look distinctly like conglomerates and are at present considered as such. They outcrop at about two and a half miles north of lake Pasho-Scoota, southeast of the lake on the north boundary of township 29, range 26, near Evans creek, and on the eastern side of the Magpie on Cradle Creek, less than a mile above its mouth. At the last-named place the fragments of granite and granitic rocks are particularly common in the matrix. One thing that may be remarked in connection with these doubtful conglomerates is that they always occur close to the edge of the granite.

Bands of conglomerates appear on the southern boundary line of township 28, range 26, at and below McKinnon's bridge, at the Steep Hill portage on the Magpie, and near Black Trout lake, and a wide area extends eastward from the mouth of the

Doré river for some six miles. The Doré river band has been described by Professor Coleman[16] and need not be mentioned here. The Doré conglomerate southwest of Black Trout lake has, as has been mentioned, a ground-mass very much resembling a quartz-porphyry schist. The pebbles consist chiefly of quartz porphyry, granite, and quartz, though narrow lenses of dark greenish material may represent drawn-out green schist pebbles. Often the rock has a distinct agglomeratic appearance, and may indeed sometimes be an agglomerate.



Gneiss-agglomerate, Cradle creek, Michipicoten.

The conglomerate which occurs just above and just below McKinnon's bridge on the Magpie river, contains pebbles much squeezed and elongated, parallel to the foliation, and varying in size from those visible with the microscope up to others six inches long. Felsite and acid porphyrites are the commonest pebbles, but several of rusty chert may also be observed. The phyllites which appear on the right bank of the river just below the conglomerate, are apparently of the Doré formation. They are for the most part almost black, but have interbanded, much narrower bands of light gray phyllite, which is sometimes somewhat coarse-grained and resembles a graywacké. The outcrop shows well the relationship existing between true bedding and cleavage. The bedding planes strike N. 34° W., whereas that of the planes of schistosity (or slaty cleavage) is N. 60° W. The true dip also is vertical, whereas the dip of the planes of schistosity is in a northeasterly direction at about 60°. The outcrop very strongly resembles that of phyllites and arkose on Reed lake already described. It has already been mentioned in describing that occurrence that the age of these rocks was uncertain, and they may in reality be Upper Huronian.

In the western Huronian area, outcrops of the Doré formation are rare. There is a characteristic exposure of Doré conglomerate with associated phyllites just east of the mouth of the Dog river. This band runs in a direction N. 40° W., and I

16 Eighth Rep. Bur. Mines, 1899, p. 132; Ninth Rep., 1900, pp. 183-4, and Eleventh Rep., 1902, pp. 155 and 162.

believe crosses the Dog river a short distance above its mouth. The most common pebbles are of granite, and next to granite those of chert. The schist pebbles are much flattened, and all pebbles are elongated parallel to the foliation. None of the pebbles are very large, those six inches long being about the longest. There is a wide outcrop of Doré conglomerate near the eastern branch of the Pucaswa river, southwest of lake Ellen. The ordinary pebbles occur and the matrix is of characteristic appearance. The width of the band is at least a mile at the widest point, but in this distance earlier rocks than the Doré conglomerate appear at the surface and indicate the removal by erosion of part of the conglomerate, and the laying bare of the underlying rock.

It is impossible to estimate the thickness of the conglomerate in northern Michipicoten, owing to its complexly folded character. It has been observed that its width south of Iron lake is at least a mile. At this point folding is particularly close, and its beds are almost all standing in vertical attitude. It is probable that the thickness is many times repeated. Secondary structures are strongly developed. Cleavage and schistosity are parallel to the axes of the isoclinal folds, and to the boundary between the Helen formation and the Doré formation. Truly ascertained bedding is seldom seen, excepting in the more slaty varieties of the conglomerate. In the conglomerate occurring just east of the Dog river, considering the dip to be uniform at 90° or vertical across the bed and presuming there is no reduplication, the width and thickness correspond at 109 + yards (68 yards conglomerate and 41 + yards phyllite).

THE POST-HURONIAN ACID ERUPTIVES

NOTE.—To accord with the new system of Archean nomenclature, and also to correspond with previous mapping of the region by Professors Coleman and Willmott, these rocks should, in part at least, be called "Laurentian".—T.W.G.

The post-Huronian acid eruptives consist of granites, felsites, syenites and quartz-porphyries. These rocks are all more or less sheared, but never as much so as are the acid schists which they intrude, and this fact is occasionally a method of distinguishing them from the older rock. As they are intrusive through the Lower Huronian schists, and the Helen formation, as well as through the Upper Huronian Doré conglomerate, they are of course younger than these formations. This relation is obtained from ample evidence seen along the contact of the granite with the various formations, and representative instances will be given later.

So far as certainly known, all the post-Huronian acid igneous rocks were eruptive rather than effusive, but some of them may have been the latter, as shown by an isolated example to the northwest of Iron lake, where a devitrified lava, probably a trachyte, with a felsitic ground-mass, shows faint evidence of flow-structure, From this single occurrence little information can be gained, but doubtless very careful study along the contact of the Huronian rocks with the post-Huronian acid eruptives would do much to elucidate this as well as many other difficult problems.

Petrography of the Eruptives

From a textural standpoint the acid eruptives are divisible into two distinct phases—the porphyritic facies, and the granitoid facies. To the former belong not only the quartz porphyries, and syenite porphyries, but the felsites which are always more or less porphyritic with feldspar phenocrysts. To the latter belong the granites and syenites.

The post-Huronian quartz-porphyry does not differ materially in macroscopical appearance from the rocks of the same species belonging to the Lower Huronian, save as a rule in that the former is less porphyritic, fresher, and somewhat less strained than the latter, but sometimes near the contact they are almost indistinguishable.

The typical quartz porphyry shows an aphanitic ground-mass dotted with various phenocrysts. Beneath the microscope the ground-mass is seen to be almost microfelsitic in texture, and to consist of various feldspars (hardly recognizable but probably orthoclase, microcline and acid oligoclase) with biotite, hornblende, and quartz. Muscovite is a common secondary product of the feldspars, and with it is often associated some carbonate. The biotites are often chloritized. Pyrites is a common accessory. In this ground-mass are embedded the comparatively large phenocrysts of quartz, with others of orthoclase and acid oligoclase. Many of the quartzes are granulated, and those which are still intact show undulatory extinction. The feldspar phenocrysts, always strained, are surrounded by a halo of degradational minerals.

By an increase in the quantity of feldspar and in the ground-mass, and by a decrease in the number of phenocrysts, the quartz-porphyry grades into a felsite. By a decrease in the quantity of quartz both as phenocrysts and in the ground-mass, and a relative increase in the number of feldspar phenocrysts and of biotite and hornblende in the ground-mass, the type passes into a mica syenite porphyry. This is really the transitional rock between the rocks of porphyritic texture and those of granitoid texture, for though it contains numerous phenocrysts, the ground-mass is not felsitic but granitoid. In some cases the phenocrysts are so common as almost to exclude the ground-mass. They are often large and consist of oligoclase (An_{28} Ab_{72}) microcline and microperthite. Oligoclase in large automorphic plates is the most common species. It occasionally shows zonal decomposition, and is with the other feldspars much squeezed, sometimes comminuted, and often surrounded by rings of secondary minerals. The ground-mass contains the original minerals biotite, quartz, apatite, titanite, pyrite and the feldspars. Biotite is not a very common mineral, and is sometimes chloritized. Quartz is rare, but secondary chalcedony has developed from the decay of the feldspars. Apatite occurs as inclusions in the feldspars and even in pyrite. Titanite is common within all the feldspars as small irregular rhomboids and occurs independently in large granular masses. Pyrite exists in regular square and triangular forms. Calcite, muscovite and secondary microcline are alteration products of the original feldspars.

From the ground-mass of the mica-syenite porphyry the normal granite type differs only in an increase in the amount of quartz and a decrease in the amount of plagioclase, as compared with orthoclase. As a rule it is a medium to coarse grained rock containing the following original minerals—quartz, microcline, orthoclase, oligoclase, biotite, rarely hornblende with titanite and apatite. The rock is always sheared, all the minerals show strain, and zones of granulated quartz with various metamorphic minerals; muscovite, epidote, chlorite, calcite, etc., occupy the spaces between the larger but always more or less corraded individuals.

By a decrease in the quantity of ferromagnesian minerals the normal granite passes into a quartz-microcline granite, almost free from ferromagnesian minerals. By an increase in the ferromagnesian minerals, and by a decrease in the amount of quartz, the rock becomes a hornblende granite or normal syenite. The quartz microcline granites, hornblende granites, and syenites are all common rocks in the acid eruptive complex of Michipicoten.

The post-Huronian acid eruptives which enclose the areas of Huronian rocks, are of extremely irregular outline, but they are all apparently connected with the immense area of gneissic and granitic rocks which form such a prominent part of the Archean of Central Canada. However, considering the slight knowledge of the granites and gneisses lying north of Michipicoten, this may seem rather a bold statement, and it is probable that there are granites and gneisses of more than one age in this huge complex.

Distribution of the Eruptives

Beginning at the Magpie river on the east, the boundary of the acid eruptives may be traced as follows. The boundary crosses the Magpie about one mile south of the foot of the Long Rapid. It then strikes northwesterly, north of the lake on

the northern boundary of township 29, range 26. Thence it follows a somewhat westerly course to the eastern end of Kabenung lake, and beyond that body of water north of lake Charlotte to lake George. It then suddenly turns east, and crossing the Dog river near the mouth of the Crayfish, it continues an eastward course south of lake Charlotte. Thence it bends southeastward, and encloses Big island of Kabenung lake, forming the Kabenung granite boss. From Kabenung lake the boundary sends off an apophysis which cuts the Helen formation at mount Raymond. It then bends north and recrosses the Dog river at the head of the rapids, just north of Heart lake. From the Dog river its course is in a general west-southwesterly direction, as far as a point about seven and a half miles west of Ellen lake. Here the Huronian rocks seem to die out, and the granite boundary turns east, and running first in an east-northeasterly direction and then straight east, it crosses the Dog river just below the mouth of Ekinu creek. Thence it continues eastward and crosses the northern arm of Jimmy Kash lake. From Jimmy Kash lake it runs northeastward to Lac Poisson

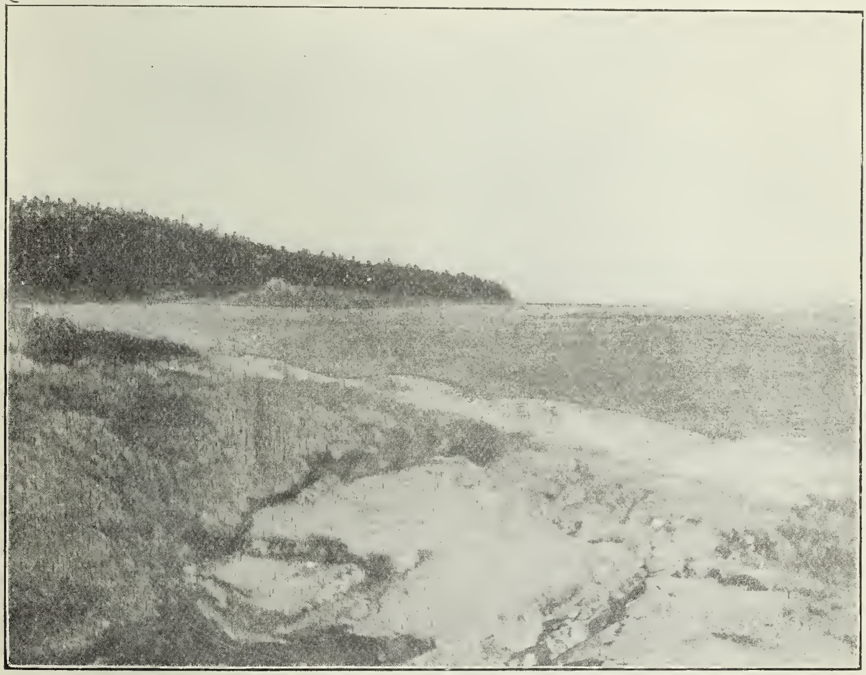
Jointed granite, Lake Superior shore, near Eagle river.

Gris and encloses Leach lake. From Leach lake it bends southerly and then south-westerly, crossing the southern boundary of township 31, range 26, near the crossing of the Doré river. Thence it bends southeast almost to Catfish lake and then turns more southerly to Black Trout lake. From the southern end of Black Trout lake it pursues a general southwesterly course, south of Doré lake, reaching the shore of Lake Superior between the mouth of the Doré and Little Bear rivers.

Occasional very small isolated outcrops of Huronian rocks are said to appear along the shore of Lake Superior westward from the mouth of Little Bear river; but no decided Huronian area is seen until a point about one mile west of Mountain Ash river is reached, and this may be said to be the boundary between the post-Huronian acid eruptives and the Huronian rocks. From here the line between the two series runs northeastward to the Dog river, which it crosses about eight miles above its mouth. It then turns southward and crossing the western bay of Duck lake, it continues the

same course for about two miles, where it bends eastward to a point about three miles north of the mouth of the Eagle river, whence its course to the Lake Superior shore is about south.

For fifteen miles west of the Eagle river granites prevail along the Lake Superior shore, then near Pilot harbor schists reappear. The boundary between the schists and the granite strikes north-northeast from this point to the eastern branch of the Pucaswa river. It then bends in a generally easterly direction to the shores of lake Michi-Biju, of Michi lake, and of Katzenbach lake. Thence it turns south follows close to the eastern margin of Katzenbach lake, and then bends west around the south of lake Michi-Biju. From the western bay of this body of water it strikes south-southwest to Floating Heart lake, whence it runs west-southwest north of Lost lake and Maple lake. West of Maple lake it bends easterly again and pursues a general east-southeasterly course for about six miles, then it turns northeasterly



Laurento-Huronian contact, near Eagle river, Lake Superior.

for four miles, and then generally easterly for four miles as far as the crossing of the boundary of the Michipicoten Mining Division. Thence the boundary gradually circles around from east to northeast, then north, and then northwest, and finally west to Miron lake. From Miron lake it bends northwesterly as far as a point three and a half miles west of Ellen lake. From this place its course to the Lake Superior shore is about west-southwest, a distance of some miles. I have placed the boundary between the post-Huronian acid eruptives and the Huronian rocks on the point between Richardson's harbor and the mouth of the Imogen river. Previous geologists in the area have put it at Otter Head, some six and a half miles farther west. I have placed it on the point west of the Imogen because the few areas of schists which appear west of this point are small and unimportant, and are apparently merely inclusions within the predominating granite. On the other hand, no prominent areas of post-Huronian acid eruptive rocks occur eastward from this point until the large area of granite near Pilot harbor commences.

Besides these large areas of granite which enclose the Huronian rocks, there are many dikes and bosses of post-Huronian acid eruptives which are found within the limits of the Huronian rocks.

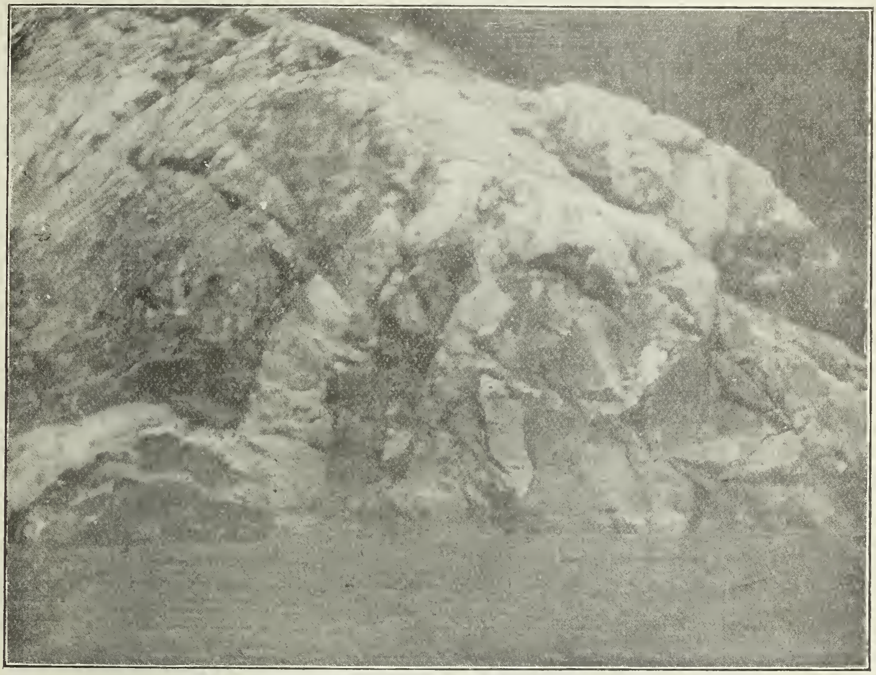
Contact with the older rocks

Among the post-Huronian acid eruptives there is a tendency to assume the porphyritic or felsitic phase towards the contact with the older rock, while away from the contact the coarse-grained granitoid type prevails. Furthermore, it was noticed that these porphyritic or felsitic rocks were in some places near the contact so schistose that often they closely resembled the Lower Huronian acid igneous rocks, and the boundary was in these places, in consequence, delineated with some difficulty. This highly foliated phase of the acid rocks is more common towards the edge of the main mass, or its larger offshoots than in the less prominent bosses, and often the smaller apophyses injected into lower formations are coarse-grained. It may be presumed that the latter were intruded in depth, while the former owe their porphyritic and felsitic character to intrusion not far from the cooling influence of the surface.

Anticlinal structure, shown by folded sheet of granite, near mouth of Eagle river, Lake Superior.

A very interesting contact is that seen north of lake Charlotte. This body of water is situated in the long, narrow, westwardly opening embayment of Huronian rocks bounded to the south by the Kabenung granite boss, and to the north by the main mass of post-Huronian acid eruptives. The contact here described is probably many times repeated along the edge of the Huronian areas, but at this particular point it is better shown than elsewhere because all the vegetation has been removed by a fire which swept the country around lake Charlotte. The rocks exposed along the northern shore of the lake include banded rusty cherts, hornblende schists, micaceous schists and epidote schists. The hornblende schists are for the most part banded

cherts changed by contact metamorphism, and the micaceous and epidotic schists, chloritic schists similarly altered. With them are interstratified narrow, very light colored silicious quartz-porphyry sheets. Passing northwards from the lake the sheets of quartz-porphyry and gneissic felsite increase in number in the schists, the sheets become wider, and the bands of schist narrower and more intensely metamorphosed. Numerous apophyses connect the various sheets. Still farther north the irruptive rocks prevail over the invaded, and at a little more than a quarter of a mile back from the water alone appear.



Folded sheets of granite (?) or felsite (?) near mouth of Eagle River, Lake Superior.

South of lake Charlotte and between that body of water and Nematequin lake occurs the contact of the green schists with the Kabenung granite boss, which is entirely different from the northern contact. It is abrupt, decided and closely demarcated. The granite is coarse-grained and often porphyritic, encloses numerous fragments, and sends off short apophyses into the schists.

The best visible contact of the acid eruptives with the Helen formation is that seen at mount Raymond, just west of Paint lake. Here an arm from the Kabenung granite boss cuts across the belt of Helen sediments. The alteration of the Helen sediments to various amphibole schists, of the slates to epidote schists, and the occurrence of wide veins of quartz and of deposits of very impure magnetite—all contact phenomena due to the intrusion of the huge granitic mass—have already been described. The changes in the intruding rock a gneissoid granite porphyry, are also interesting The immediate edge of the boss is highly foliated and towards the centre it is coarse-grained and but slightly schistose. Numerous fragments both of the iron formation and of the schists which border it, are enclosed within the irrupitve toward the edge.

The eruptive relations of the post-Huronian acid igneous rocks with the Doré formation are not so well shown in the northern part of Michipicoten as in the southern part. However, on the shores of East Kabenung lake and to the south of lake Charlotte, narrow dikes of granite, apophyses from the Kabenung granite, cut the

formation. An excellent contact of the Doré formation with the post-Huronian granite occurs on the Lake Superior shore a few miles west of the Doré river, and distinctly shows the irruptive relations of the latter.

Somewhat interesting is the geological section exhibited along the Lake Superior shore from Otter Head eastward. Owing to the constant washing of the waves the rocks are excellently exposed, and the relations existing between them well shown. At Otter Head the rocks consist of small areas of evenly banded gneiss, ordinary light reddish granite, coarse-grained pegmatite, quartz and calcite veins, and diabase. The gneiss is composed of alternating bands one-quarter of an inch and less in width of dark colored minerals, chiefly biotite, and of light colored minerals, chiefly ortholcase, oligoclase and quartz. The light colored granite, which is probably the commonest rock, is a typical post-Huronian eruptive. The pegmatite, consisting chiefly of large individuals of feldspars, quartz and biotite, was probably formed as the result of steam acting upon the hot granitic magma, either during or immediately following its intrusion. The veins are later than either granite or pegmatite, but probably they owe their origin to the circulating thermal waters which followed and were the result of the granitic intrusion. Eastward from Otter Head the inclusions of gneiss appear of finer grain, though always very evenly banded. Gradually they become more common, increase in width, become definite bands alternating with areas of granite and more closely resemble the ordinary types of schist. Sometimes the bands of schists are crossed by dikes of granite joining two sheets of this rock. Finally, at about six and a half miles east of Otter Head, the granites give place to the schists and the latter become the prevailing rock.

The patches of acidic gneiss which occur at Otter Head are interesting as exhibiting a rock which is very common in the acid eruptive complex stretching northward towards James bay, often in considerable areas. It is my opinion that this acid gneiss represents a much metamorphosed quartz-porphyry or the metamorphosed plutonic equivalent of a quartz-porphyry, and that it is of the same age as the Lower Huronian acid schists. My reasons for thinking that this gneiss is of the same age as the Lower Huronian schists are:

(1). All around the contact of the post-Huronian granite with the Lower Huronian schists, we find these areas of gneiss, and there seems often to be gradual transitions between the true gneiss and the schist inclusions, similar to but more metamorphosed than those schists outside the granite. (See north of lake Charlotte).

(2). There is no evidence of greater straining of the minerals composing the gneiss than of the minerals composing the quartz-porphyry schists.

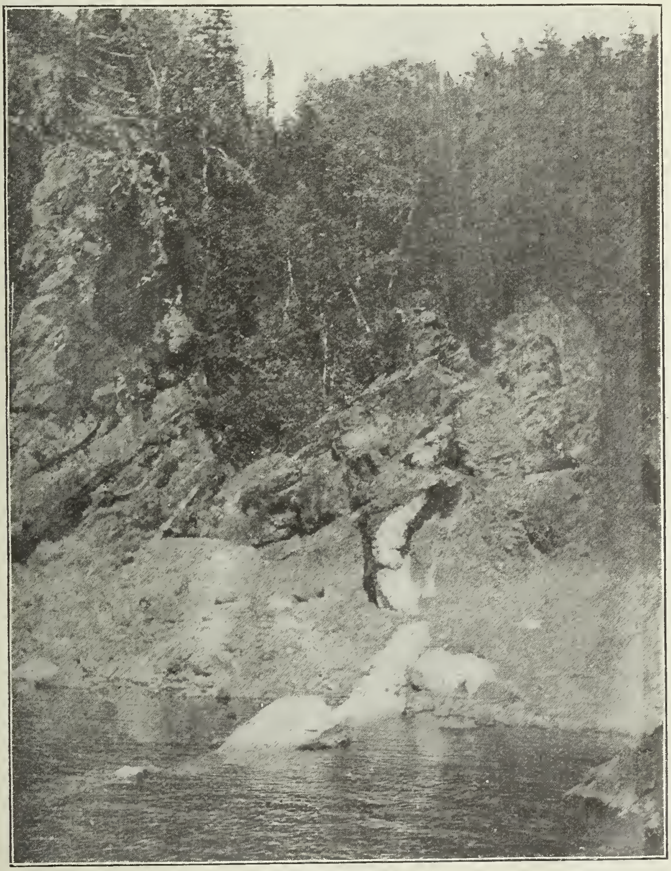
(3). There seems to be no unconformity at the base of the Lower Huronian (if for that matter we know what rocks of the Lower Huronian lie at its base).

I have mentioned the fact that there is found very commonly in the Doré conglomerate a certain sort of granite pebble very characteristic of that formation, and that no earlier granitic rock is known which could have supplied these pebbles. Now this granitic rock must either have been entirely removed or completely covered by later rocks, or else have changed its state, been re-fused or re-granitized. It can hardly have been altogether removed or covered because the area is large and the granite pebbles of this sort occur everywhere within the Doré conglomerate. In favor of the hypothesis of a change of state there seems to be visible support in the many areas of acid gneiss within the granites,[16] and in the fact that these gneisses wherever they occur, have a peculiar irregular contact with the granite, as if the gneisses had been re-fused or in some way re-crystallized. Perhaps the word "re-granitization" is better than "re-fusion" since in our present knowledge of granites it is not known whether or not they are a product of fusion. Thus the areas of gneiss may represent the metamorphosed remnant of the rock, from which the granite pebbles of the Doré

[16] These areas of acid gneiss greatly predominate over the granites in the acid igneous complex, especially northward away from the contact. The gneisses and granite are generally classed together as Laurentian and are often very difficult to separate; but it will be understood that the granites and allied rocks are considered Post-Huronian—the gneisses, Lower Huronian.

conglomerate were derived. During the folding of the Huronian rocks and in the main the direct result of it, came the re-granitization of the Lower Huronian acid igneous rocks, which must have existed in quantities largely predominating all other rocks and the consequent intrusion of vast masses of granites and allied rocks. This is rather too large a question to be considered here in further detail.

Most of the quartz and calcite veins which appear in Michipicoten were the direct result of the granitic intrusions. Some smaller quartz veins must have existed before Upper Huronian times, as evidenced by the presence of quartz pebbles in the Doré conglomerate. The post-Huronian veins are probably for the most part of the type of fissure veins. Veins are rare in northern Michipicoten, but they are of common occurrence in the western area. Just at Otter Head there is an interesting vein of



Big quartz vein, Lake Superior shore, near mouth of Pucaswa river.

orthoclase and calcite, parallel with the structure of the gneiss in which it is enclosed, and with a width of from eight inches to one foot. Several prominent quartz veins outcrop on the point between the mouth of the Imogen river and the Pucaswa river in a soft felsite schist. One vein containing both pyrites and chalcopyrite, is about 3 feet 6 inches wide at its widest part near the lake shore, from which it narrows in either direction. To the north about seventy-five feet another vein appears, and this may be the same as the one just described from which it has been faulted, the plane of the fault being occupied by a diabase dike. A short distance still farther north along the shore another vein appears prominently both above and below the

water. It rises as a ridge two or three feet high above the gravel of a small bay, and four or five feet beyond in the enclosing schists. It is three feet wide and dips vertically, lensing out upward in the schists. Both veins are apparently quite barren.

Small calcite veins are common in schists along the walls of the falls near the mouth of the Pucaswa river. From the Pucaswa river southeastward along the shore numerous veins show up, in some of which a little prospecting work has been done, but nothing of commercial value obtained. A small calcite and quartz vein about one mile from the mouth of the Pucaswa river was found to carry gold to the value of $4.40 to the ton, and copper to the extent of 3.85 per cent. A specimen from another vein of quartz near a small shack on the lake shore about five and a half miles southeast of the mouth of the Pucaswa river on analysis gave traces of gold.

A somewhat remarkable mass of quartz occurs near the mouth of the Eagle river, which I believe was originally staked as an iron location. Its width is about forty feet and its length is traceable for about a hundred and twenty-five feet, disappearing in either direction beneath the drift. In character it is often stained rusty or red by iron oxides, again it appears kaolinic or jasperoid, at other times it resembles greenish chert. It seems to cut the enclosing green schists, but these are much contorted and this relation could not be definitely ascertained. Stringers of calcite traverse the quartz mass in one place at least. Sometimes the mass appears brecciated

A deposit of molybdenite is found in a coarse-grained quartzose pegmatite on the shores of Molybdenite lake on the route between Michipicoten Harbor and the Frances mine. I was unable to visit the locality during the past summer, but I understand that the deposit is not of commercial importance, as proven by some exploration work done on the property some years ago.

THE POST-HURONIAN BASIC ERUPTIVES

In northern Michipicoten the post-Huronian basic igneous rocks are apparently never effusive, but eruptive. They have a wide though limited distribution throughout the entire area, and being the youngest rocks in the district, they cut all the lower formations, including the post-Huronian acid eruptives. They occur as numerous narrow dikes cutting the sediments and enclosing rocks, as elongated bosses included within the schists, conglomerate and granites, and as narrow sheets, generally offshoots from the wider bosses, especially apparent when occurring within the Helen iron formation. Sometimes the dikes are of economic value, along the iron ranges, by creating dams against which iron ores may be deposited by iron-bearing solutions passing down troughs leading to the dikes. The sheets on the other hand are usually detrimental by retarding the lateral flow of iron-bearing solutions, and by giving a smaller area from which ferruginous material can be drawn.

The most important bosses are those intrusive in the schists and granites north of and southeast of Paint lake, that one occurring south of lake Michi-Biju and extending east to Katzenbach lake, and that one cutting the schists and Helen formation near David's lakes. The sheets are most evident at Brotherton hill, and along the MacDougall promontory at Iron lake, where their occurrence within the iron formation has already been briefly mentioned. The narrow dikes are seen commonly everywhere, and are especially evident along the Lake Superior shore.

Petrography of the Basic Eruptives

All the post-Huronian basic rocks are of the gabbro family and consist essentially of a light colored pyroxene, probably diopside, of a basic plagioclase (maximum extinction $+32°$ on 010) and of more or less magnetite or ilmenite. With these primary minerals are usually associated a variety of secondary minerals. The pyroxene is frequently replaced by the paramorphic amphibole, uralite, and less commonly by

biotite. Chlorite is the principal final product of alteration. The plagioclase alters to mixtures of epidote, quartz, muscovite and carbonate. Olivine, though rarely seen, is in some few places quite common, and serpentine often indicates its former presence. Most of the bosses and wider dikes away from the influence of the iron formation show fairly fresh, very little strained rocks, but the sheets and dikes connected with the Helen formation are always extremely changed and consist of a structureless mass of chlorite, epidote, decomposed felspars, quartz, leucoxene, and carbonate. These metamorphosed rocks are often with difficulty recognized as of igneoous origin. The extreme phase is seen in the chloritic sideritic schists which intercalate with the iron formation at Iron lake and elsewhere, and many of which were at first sight considered as sedimentary rocks.

From a textural standpoint the basic eruptives show several facies. The most common of these are the coarse-grained granitoid phase, and the finer grained sometimes aphanitic ophitic phase. Lamprophyric rocks are rare.

The granitoid type is represented by the true gabbros or dolerites. These, often coarsely crystalline, are the prevailing rocks in the larger bosses and show no especially remarkable features. Frequently they are altered to epidiorites, and their margins are often strongly magnetic.

The ophitic type is shown in the diabases, which sometimes occur as a textural differentiation on the edge of the larger gabbro bosses, and also in many of the smaller bosses, in all the smaller dikes, and in most of the intrusive sheets, though as has been said, the original character of all dikes and sheets occurring within the iron formation has been lost

INDEX

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